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October, 1955 Vol. 46, No. 2

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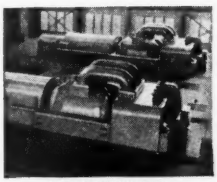
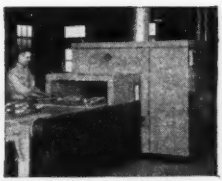
Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: W. L. Collins, Chairman, L. E. Grinter, N. W. Dougherty, F. M. Dawson, G. W. Farnham, E. A. Walker, C. E. Watson, Editor. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the act of August 12, 1912. Subscription Price, $6.00 per year; Yearbook Issue, $6.00; Single Copies, $1.25.





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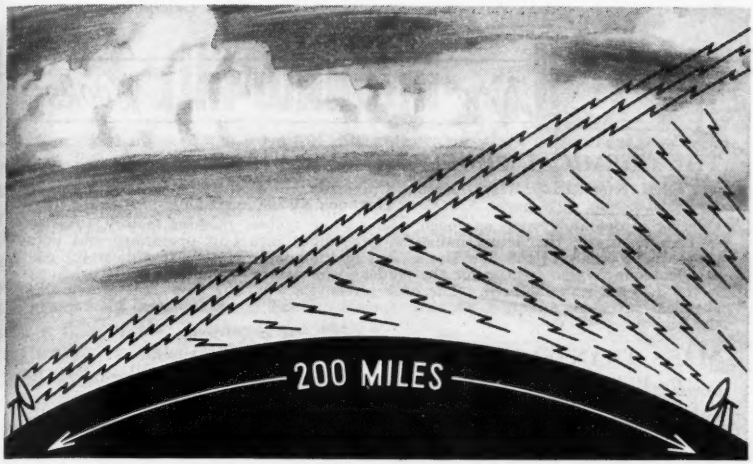
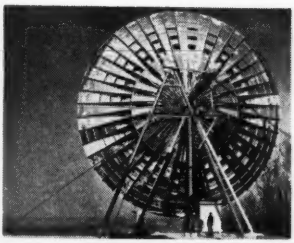


Highly schematic drawing illustrates the possible distribution of energy in ultra-high-frequency "over-the-horizon" transmission. The effect is similar to that of a powerful searchlight whose beam points into the sky. Light can be seen miles away from behind a hill even when the searchlight lens is invisible.

Something new on the telephone horizon



This experimental 60-foot antenna (rear view) photographed at the Bell Laboratories in Holmdel, New Jersey, is designed for study of "over-the-horizon" phenomena.

Telephone conversations and television pictures can now travel by ultra-high-frequency radio waves far beyond the horizon. This was recently demonstrated by Bell Telephone Laboratories and Massachusetts Institute of Technology scientists using "over-the-horizon" wave propagation, an important recent development in the radio transmission field.

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Do You Know—

▶ One of the aims of your Editor and Secretary for the coming year is to get each issue of the JOURNAL to you during the month of issue. Perhaps we shouldn't "stick our necks out," but we want you to know we are going to try. There will be some problems and some departures from custom may need to be made. That is particularly true of the *Yearbook*, the February issue. It is the chief cause of delay and the enrollment and degree statistics may have to be published in another issue. And in regard to the *Yearbook*—we get complaints about it not being up to date. But did you send in your change of address card promptly? The *Yearbook* can be only as good as the members make it.

▶ The Technical Institute Division is organizing its forces for a big job—a book on Technical Institutes and Technical Institute Education. The project is made possible by the generous gift of securities valued at about $6,000 by Arthur L. Williston, retired principal of Wentworth Institute. Mr. Williston, a member of the Society since 1897, was a vice president of the Society in 1909–10, Secretary in 1907–09, and a member of the General Council in 1900–03 and 1905–08. He is also the third recipient of the James H. McGraw Award, 1952. The Society is grateful to Mr. Williston for his generosity in making possible the preparation of a much needed book on Technical Institutes. The committee appointed to prepare the book consists of Professor H. P. Adams, F. E. Dobbs, M. R. Graney, S. C. Hollister, Miss J. Miller, B. T. Thorogood, and Mr. A. L. Williston.

▶ The program of the Annual Meeting of Engineers Joint Council is to be devoted to a discussion of technical institute education. ASEE and ECPD have been asked to cooperate in the planning; each organization will have two representatives on the planning committee. The nature and scope of technical institute training and the relation between such graduates and engineering graduates in an attempt to meet our engineering manpower needs is the central thought of the meeting. Representatives from industry and the armed forces will be invited to participate in this discussion of the effective use of engineering technicians.

▶ The Committee on Evaluation of Engineering Education has been discharged. It has done a monumental task and is to be highly commended for its work. To its chairman, Dean L. E. Grinter of the University of Florida, to its secretary, Professor D. H. Pletta of Virginia Polytechnic Institute, and to each member of the committee, the Society owes a deep debt of gratitude and appreciation. A pattern has been developed for the future and our sights now can be focused on objectives. The next step is implementation, and to be sure something is done it is proposed that a new committee be appointed, its membership composed of the chairmen of Divisions. The committee will work out its own plans and procedures.

▶ The Teaching Aids Bulletin committee also has been discharged. With the publication of the *Educational Aids Manual* the work of the committee has come to a close. The project, however, should not be thought of as dead; there are additional areas of engineering to be covered and funds are available for the work if the need exists and the interest is evident. Carl W. Muhlenbruch of Education and Technical Consultants, Inc., spent a tremendous amount of work on this project; he and all who worked with him are thanked for their efforts. The Manual has been a success; the first printing is almost exhausted and plans are being made for reprinting.

▶ The third ad hoc committee to be discharged is Printing Economy, G. W. Farnham, Chairman. A committee by such, or similar, name is appointed about

every five years to study the cost of printing the JOURNAL OF ENGINEERING EDUCATION. In its latest study, it reported the prices charged by Lancaster Press were reasonable and that they were giving excellent service. A few odds and ends remain to be checked, but our Treasurer, G. W. Farnham, has been asked to report directly to the Executive Board.

► *"Aim for Ames in '56"* will be seen and heard many times during the coming year. It will be the phrase most frequently used in the publicity for next year's Annual Meeting at Iowa State, June 25–29. Mark the date on your calendar and *"Aim for Ames in '56."*

► The YET Committee has agreed to conduct an active membership drive as part of its program for the coming year. They have done a good job in the past and will do so again. It is hoped every institution will have an active YET group working on membership. Comments received at the Annual Meeting indicate that some schools are planning their own campaigns for all members of the faculties; some said each of us should do more as individuals. Anyone wanting application blanks can get them from the Secretary's office. The *Yearbook* always contains a membership application form, but for everyone's convenience, now that a new school year has just started, an application blank is printed below. Give it to a friend, have him fill it out and mail it to the Secretary's office.

W. Leighton Collins,
Secretary.

Return to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Ill.

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An Administrator Takes a Look at General Studies for Engineers

By JESS H. DAVIS

President, Stevens Institute of Technology

As far as I can tell, the excitement about teaching the humanities and social studies in engineering colleges broke out sometime in the 1920's. I'm not sure why it all started just then, unless it was that during World War I, American industry made its influence felt on a grand scale for the first time. And American industry was built, in large part, by engineers. Apparently, someone decided right then and there that engineers might become rather important people in our society one day and that they ought to try to pull themselves above the vocational category in which many people placed them—and with some justification as we all know.

Engineers were painted by some as noisy louts with dirty fingernails who never had anything to talk about at faculty teas except nuts and bolts. It was said that they didn't know how to express themselves, they had no knowledge of art or history, of literature or economics and couldn't even conjugate a Latin verb. Someone decided that, if these men were to become important in the scheme of things, they would just have to acquire some "culture." It never *was* explained just what was meant by "culture," but before anyone knew it, the panic was on.

After some sage head-waggings on the part of deans and presidents, engineering schools that didn't already have them, started installing courses, even programs in the humanities. "Culture for Engineers" became the by-word and before long the bright young man whose only ambition was to build a bridge or design a dynamo was trying to use his integral calculus to decipher the writing of someone named Geoffrey Chaucer.

Today, after the passage of some thirty or thirty-five years, you can attend faculty teas—or literary cocktail parties—and *still* hear people talking about engineers. And what they are saying is: "Engineers can't express themselves adequately, they don't appreciate art, history, literature or economics and they *still* can't conjugate Latin verbs."

Well—maybe these critics are right. But a new sound is being heard these days. When engineers get together—with their nails now carefully cleaned—they are starting to make many of the same comments about some of the graduates of our liberal arts colleges. They go one step further and point out that when it comes to clear, logical and independent thinking, too many of the liberal arts graduates are —to use the elegant phrasing of an English literature major in a Madison Avenue advertising agency—"out in left field with prunes in their mouths."

Now, I think the social-humanistic programs in most of our engineering colleges —including my own—leave much to be desired. In some instances, I think this probably stems from the fact that too many engineering administrators were anxious—back in the twenties and thirties —to get on the "Culture for Engineers" bandwagon. And they did it without thinking through what they hoped to ac-

* Presented at the Annual Dinner of the English and Humanistic-Social Divisions, ASEE, Penn State University, June 20, 1955.

complish or whether what they were doing was going to accomplish it. In fact, I'm not sure but what most of us are still a little fuzzy about objectives.

Objectives

No one can quarrel with the objectives set out by the several committees of this society and others regarding the social-humanistic stem. But, I wonder whether those objectives aren't too general and too broad in scope for us to even hope to realize. Certainly they are too general and unwieldy ever to admit of measuring results. Now I am fully aware that the values we hope to impart through the teaching of literature and history and philosophy and art and music are not measurable in the cold mathematical sense. But I do believe that we can arrange our courses of teaching in such a manner as to provide a continuing comparison of achievements with previously stated goals.

We set forth as the objectives of the humanities program such things as these: "to foster an understanding of the forces that have shaped modern society and to develop an appreciation of great achievements in literature, philosophy and the arts so that students may become alert and informed men, able to recognize true values and place engineering in its proper relation to other human endeavors." Now, I agree that that is a fine statement, carefully shaped after solemn declarations of objectives by this society. In fact, it had better be a good statement—it comes from the current Stevens Catalog.

But, as I said at the outset, I am confused. One reason is that as an administrator who is supposed to keep an eye on the big, broad picture, I have no way of determining whether we are within several city blocks of the goals described in that statement.

I am perplexed by such words as "understanding"—"to foster an understanding of the forces that have shaped modern society." What kind of understanding—how deep, how broad, how extensive? Just how much understanding of such vaguely defined objectives can you humanly expect a student to absorb during twenty or twenty-five semester hours of study per week spread out over four years?

Again, what are "true values"? I confess I don't know. Of course, I'm an engineering school graduate myself and didn't have time to delve too deeply into the conflicting interpretations of this term by the various philosophers and poets. But maturity and experience and observation should be worth something, and yet I'm sure I couldn't give you a definition of "true values" that would satisfy more than ten per cent of the people in this room. Yes, you may say, "Of course, there's no real, universal definition of 'true values,' but we all know what it means." And I say to that, "That's a pretty sad way for an engineer to talk."

What I'm driving at is this: The sequence of mathematics and science and engineering courses each engineering college offers has a definite objective in mind. In very general terms it is to give a young man a certain amount of knowledge in the productive use of nature's forces and materials. This objective is predicated on what we believe are the requirements for a background upon which the graduate can build a broader or deeper knowledge of science and engineering as he pursues his activities in one or both of these areas. When the young man has met the requirements of the courses within the sequence he has automatically achieved the technical objectives of his college course and he satisfies, at least to a degree, his own desires and those of the industry in which he will be employed. Now, what I'd like to ask is this: "Can't we pursue this same method in the social-humanistic area? Can't we sharpen up objectives, then shape a program that will permit us to determine, with some assurance, how close we come to meeting those objectives?"

I think such a move would be desirable if only because it might prevent us from

spreading ourselves too thin in an effort to cover the same ground the liberal arts colleges, but in a third or a quarter of the time.

It seems to me that part of our difficulty arises from the fact that, in the beginning, we attempted to boil down the non-scientific content of the liberal arts curriculum into capsulized form so it would fit into such holes as were left in the engineering curriculum by cutting down the number of courses in subjects like machine and woodworking shop, forge, foundry and mechanical drawing. (Thus, we launched a two-pronged attack on the problem of the engineer's dirty fingernails.)

Fresh Look

But isn't it time we took a fresh look at things to see whether we, who know engineering students, can't come up with a new concept that will come closer to meeting their needs? Suppose we set aside the liberal arts tradition and attempt to create one of our own—a techno-humanistic tradition that recognizes and welcomes the influence of science and technology on our times and that attempts to learn from the best of man's past and contemporary achievements how to make the wisest use of the new forces now at our command. And let's attempt to do this in a manner consistent with the methods by which we so successfully teach science and engineering.

What I am about to suggest may not seem new or bright or fresh to many of you—particularly to those of you who are teaching the humanities. Perhaps you have tried to work out similar plans and you may have very real reasons for knowing why these proposals will not work. But I can tell you that as an administrator, I for one would be happier with *some* new approach simply because it would ease my mind that we were doing something I could describe in fairly concrete terms to a board of trustees or a prospective benefactor.

The first step in establishing a new techno-humanistic stem would be to set up very firm objectives that would get down to specifics. These would be molded out of the statements of broader objectives agreed to by such groups as this one. But each objective would be divided into smaller, definable elements, and courses would be shaped to meet the requirements indicated by each. I am not going to attempt a breakdown for you because each college should make its own. Instead, I would like to ask you to examine with me, the general objectives of the social-humanistic stem as set forth in the Report of the Committee on Engineering Education After the War, issued in 1945. It is rather appropriate that we examine into this thoughtful report at this time, since the chairman of that committee was Mr. H. P. Hammond, then Dean of Engineering at our host college.

A summary of the Hammond Committee's report appearing in the Society's journal sets down five desirable objectives for the humanistic-social stem. Let's look into one of those general objectives. Take the one that advocates "an appreciation of cultural interests lying outside the field of engineering." Here again we are faced with a problem in semantics—the word "appreciation" by itself does not indicate degree or amount, and "cultural" is a term which, as I have noted, defies measurement. I am glad, however, that the statement seems to make the field of engineering itself either a form of culture or a force which affects culture.

Individual Treatment

But let's assume that, like "true values," we *all know* what "culture" means and that it is inherent in the study of subjects like literature, art, music, the theater. Now to begin with, I don't believe that these subjects can be adequately covered in a catchall course that attempts to combine all four, along with, perhaps, a study of man's social and cultural development over the ages. It seems to me that, to avoid superficiality, each of these subjects should be given individual treatment. I'm fully aware that we can't

devote a full course to each. However, I *do* think that if we carefully select certain phases of each and treat those phases in some depth—within the time limitations of the total curriculum—we can approach something like "understanding" and, perhaps, whet the appetite for independent exploration of other phases.

The selection of the phases or portions of each field to be studied is, of course, all-important. I think you will agree that the purpose of exposing a student, in any kind of college program, to greater or lesser amounts of English literature, for example, is to help him to recognize certain values in good writing, and to make him want to continue to read and to enjoy worthwhile books. But in the selection of these books, I fear, we have pretty much followed the traditionalists—an unbecoming situation for a group which prides itself that its graduates are becoming *leaders* of vast influence.

Looking at it quite objectively, are we prepared to assert that the study of the Norse sagas, of Pope, and Dryden and Dante and Milton is the best way of getting engineering students, or too many other kinds of students, interested in reading? Aren't there other authors, with equally high literary standards, whose writings are much closer to the experience of the student and which he would read with greater enthusiasm and profit—and with longer-lasting effect?

Since the engineer created and is also a product of the Industrial Revolution, wouldn't it seem reasonable to have the engineering student concentrate on the literary products of that era? Instead of asking the student to get excited about the writers of the dim distant past, why not instead give him greater exposure to writers like Bernard Shaw and Sinclair Lewis and Scott Fitzgerald and Dreiser and Hemingway and Aldous Huxley? These are men with high literary standards who have written of an era in which the student is far more at home than he is in Boswell's age. Isn't he likely to respond to them more readily—and isn't he more likely to develop the habit of reading and perhaps, in pursuance thereof, one day look up some of the older authors? Isn't this better than actually discouraging him from reading by asking him to grapple with respectable, but what he considers rather dull writers?

And why continue to make a fetish of reading Shakespeare? Since Shakespeare wrote for the theater, why not encourage students to see his plays in the theater—or in the movies? If you do, you might even find an occasional student who will read a play before seeing it on the stage or screen and one or two who might be encouraged to read another afterwards.

Speaking of plays and playwrights, isn't a student likely to take more interest in the theater if he is introduced to it by way of Shaw and Eugene O'Neill and Robert Sherwood and Sidney Howard and Elmer Rice and Sidney Kingsley than by way of Aeschylus and Euripides and Aristophanes?

The same reasoning applies to the teaching of music. Now, I'm not an afficionado of jazz, but jazz and popular music in general are a lot closer to the average student than Bach or Mozart. It seems to me that a skilled teacher shouldn't have too much difficulty in pointing out certain values in popular music that reflect those found in the work of the masters. By listening to Beethoven and Haydn in illustration of these points, the student might give willing attention to something he has before arbitrarily dismissed as "long-hair."

The study of art ought to be a relatively popular one in an engineering college, I think. I know that I have seen a good deal of painting and sculpture done by engineering students, and some of it has been quite acceptable. Why, then, don't we encourage more students to get their hands on an artist's brush or a piece of modeling clay—many of them are good with their hands and would enjoy the opportunity. If they become sufficiently

interested, they probably would *demand* more knowledge about the whole field of art. This, to my mind, is far better educational procedure than compelling students to drag themselves unwillingly through an art gallery, or to read a dry book about art.

Component Parts

Do I make clear what I have in mind? First, take the general objective and break it down into component parts. In this case, "cultural interests" can be divided into four major parts: literature, theater, art, music. You might not agree with my arbitrary sub-divisions, but whatever ones you select, I think you ought to concentrate on limited areas of each. And in selecting those areas, I think you will be wise to select those which are closest to the experience and interest of the students. I am satisfied that diligent searching will reveal them to you. As for areas more remote from the student's interests, I think some non-conformist thinking will uncover routes that will lead the student enthusiastically to them and that proper exposure will assure his continuing, self-sustaining interest.

But, above all, if you want to teach a subject—teach it. If it be the art of stamp collecting—give a course in stamp collecting. Don't rely on the student himself to get the hang of it by synthesizing the overflow from courses in paper-manufacturing, engraving, adhesives, and an interpretation of the U. S. Postal Regulations.

For another illustration, let us return to the Hammond Report. A second of its stated objectives is "acquaintanceship with the enduring ideas . . . to serve as guides to ethical and moral values." Well, if we want to teach ethical and moral values, why don't we simply give a course in ethics? Why not study the major religious faiths and the moral precepts each advances—even trace their translation into the laws and customs that affect our daily lives? If a knowledge of ethics and morals is a desired objective, why leave it to chance and hope that it will be realized as a by-product of other courses?

If we approve of the report's objective of encouraging "the development of an adequate concept of the duties of citizenship in a democratic society," are we doing enough in a concrete way to attain that objective? Shouldn't most of us be teaching more about the organization and functioning of our federal and state governments, more about the bureaus and agencies that affect the lives of the students who are part of that "democratic society"? And shouldn't we be spelling out what the "duties of citizenship" are and how they may be performed?

If we agree with the report that another objective of the humanities curriculum is to "understand and analyze the essentials of an economic, social or humanistic situation" and to "relate it to the life and work of the engineer," are we doing enough to bring out the influence of technology on our society so the student can trace the relationship? I don't mean modern technology alone, but the influence of engineering ideas on the growth of cities, in satisfying the need for food and water, in seeking sufficient natural resources, in the development of methods of transportation and communication, and on the need for energy sources?

When we start enumerating the items that are implicit in the broad objectives stated by the Hammond Report, it becomes apparent that we are attempting to cover a lot of territory in a few semester hours. So, unless we are content to settle for a thin veneer of non-technical learning, we are going to have to take the engineering approach of singling out the more important objectives and creating a workable mechanism for attaining them.

Now, to reach even a limited number of objectives we shall have to insist on each student taking prescribed courses, rather than trusting to God and electives. In saying this, I realize I am going contrary to the present trend of integration and of survey courses. But I think it essential if we are really serious about

attaining the objectives we set for ourselves.

Functional Approach

I realize, also, that this approach is a purely functional one and that it will be held in high scorn by the purist in the arts tradition, to whom functionalism is anathema. These are what I call the educational non-objectivists. They offer a plethora of courses, seldom purposefully arranged to aid the student's mature development. As a result, many a student wanders through the Groves of Academe, plucking an attractive bloom here and another there until he emerges, at the end of four years, with a beautiful bouquet and no one to bestow it upon.

Most purists are inclined to sneer at science anyway because, they say, it is concerned only with verifiable truths and there are so many more important values which cannot be measured. This betrays a disturbing ignorance of the methods and philosophy of science. As we know, science has scored its greatest triumphs by postulating entirely unprovable explanations, then using these theories to soar into rarefied regions of thought seldom inhabited by philosopher or poet. If the end purpose of education is to excite and exercise the mind, then I submit that the average program in an engineering college does this a lot more effectively than most of the non-objective programs that I know about.

So, because of the effectiveness of our technical programs, I think we need feel no hesitancy in trying to plan a disciplined approach even to the non-engineering subjects—with objectives clearly staked out in such a manner that we can gauge the degree of our success in meeting them. But just let's be sure that we describe those goals in detail and that we have the determination not to be deterred from attaining them.

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1955–56 Edition

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This publication lists all of the schools in Canada and the United States which grant degrees in Chemical Engineering. Information is given concerning each school, such as accreditation by A. I. Ch. E. and E.C.P.D.; whether or not graduate work is given; number of degrees granted last year; the academic rank, name, and academic degree held by each member of the staff. An important item listed for company personnel men is the name of the college placement officer.

For What Types of Careers Should We Train Mathematicians?*

By RICHARD S. BURINGTON †

Bureau of Ordnance, Navy Department

For what types of careers should we train mathematicians? What sort of an attitude should color the philosophy underlying the training of mathematicians, especially at the graduate school level? And, how should these principles relate to advanced work in the engineering and physical sciences? It is to these questions that I direct my attention today.

Traditionally the bulk of the graduate school effort in training mathematicians has been made with the expectation that the successful graduates will seek college or university teaching positions; and, that some will carry on a collateral career in mathematical research. A number of excellent centers for such training have existed for some time in this country. Few such centers have emphasized applied mathematics, and little emphasis has been given to training mathematicians for service outside academic institutions. Within the last fifteeen years we have seen some growth in a few of our graduate schools in the fields of mechanics and applied mathematics. Today, in engineering education there appears to be a growing tendency to organize engineering graduate schools on a fairly large scale, as distinct from the older, more conservative forms of graduate school programs.

It is time for mathematics teachers and graduate school authorities to recognize realistically the demand for men trained for a wider variety of careers in the mathematical sciences than has been the tradition in this country. Mathematics faculties must accept an active responsibility in training mathematicians for careers in industry, as well as for careers in teaching and academic research. These faculties must realize that good research, development, and general mathematicians are needed in industry as well as in our institutions of higher learning. They must organize their efforts to train such men.

In order to lay a somewhat broader background for my theme, I shall review briefly the aims of university research. Later I shall discuss, in a general way, some aspects of industrial activities that bear on the theme.

Aims

The aims of a university are (1) to help individuals to learn more, and (2) to help mankind to know more. The mechanism whereby the first goal is approached is through teaching. The mechanism to realize the second is known as research.

University research ‡ has for its purpose the enlargement of man's understanding of the world, his fellow men, and himself. University research in science, and in engineering, must depend on underlying fundamental principles.

The engineer in university research is

* Retiring address of Chairman, Mathematics Division, 1953–54, presented at Annual Meeting of ASEE, Penn State University, June 22, 1955.

† The views expressed herein are those of the author and are not necessarily those of the Navy Department.

‡ "The Goals of Research," L. A. Du Bridge, THE JOURNAL OF ENGINEERING EDUCATION, Sept. 1954.

concerned with developing new materials, new practices, new methods of design; a more comprehensive understanding of fatigue, vibrations, thermodynamics, and so on. This is in contrast with the practicing engineer who is more likely to be concerned with actual design, construction and operation of structures, power distribution systems, and the like, making use of more conventional types of technology. The university research engineer is sort of intermediary to the pure scientist and the practicing engineer in industry.

The university engineer may be involved in activities which the industrial engineer feels is the work of the scientist, but on the other hand this work may not be of particular interest to the scientist, who may be interested in other types of things.

The university scientist engaged in research is usually engrossed in the frontier problems of his field. He is typically interested in his search for the understanding of new phenomena as contrasted with the development problems of utilizing his findings. Thus the research physicist in the university may be engrossed in the problems of sub-nuclear forces, or some highly involved studies in the propagation of sound through various materials, or the like, involving difficult or abstract experiments; whereas, such a physicist may not be interested in developing the fundamentals of the technology for these fields. There is much room for fundamental engineering research in the university atmosphere. Similar situations exist in other fields.

Physicists, chemists, and engineers, engrossed as they are in their particular types of research, can all make much good use of advanced mathematical techniques. But—who is going to create and develop the as yet undiscovered mathematical principles which can be drawn upon when the need arises? Who is going to develop such principles into suitable well-knit mathematical structures which the scientist and the engineer can lean upon for a better understanding, exposition, and prediction of the newer fields which he explores? This is the business of the competent research mathematician. It is a proper field for university research. This the research mathematician has been doing for many years. Such men have brought their talents to bear with great success in the many difficult problems of analysis, algebra, computation, and the like.

And who is it that is going to have the background of knowledge of the mathematical sciences and their interplay with the sciences, upon whom engineers and scientists can draw for collaboration and help in the solution of their problems? It is the mathematician trained specifically for these fields of application. He may be a university research mathematician, but he may equally well be a mathematician working in industry as a part of a team of research workers. The latter type of mathematician is not too common, and such as exist are not always well known outside the circle of their co-workers. He may not be the author of widely published research papers, but he may well be a real research man of major accomplishments in the fields of his activities.

It is these types of mathematicians which our universities must train, not only those for a life of teaching and academic research, but also those for a life of industrial research and development work in government and industry. Do our mathematics departments thoroughly appreciate these two distinct types of careers in mathematics? Especially the latter? Only a few of them do. Something should be done about this on a much wider scale than is now the practice in a relatively few graduate schools.

Steps Involved

But the type of research that I have crudely sketched for the university engineers and physicists is not by any means currently the practice of all universities, nor is this type of activity confined solely to universities. In industry and government we find a considerable amount of all

these types of activities, especially in the domains for research in physics, chemistry, and in the search for improved engineering methods, materials, design, etc.

It may well be appropriate to review some of the steps involved in the ultimate realization of a new product, or system. I have in mind such a thing as the development of a radically new type of propulsion system, or a new type of communication system, or the like. The realization of such a new system or product may more than likely involve a multiplicity of efforts, any one of which (as well as the system as a whole) may involve the following general steps: pure research, applied research, development, construction of prototypes for study, testing, etc.; the redesign of prototypes for limited production, the limited production of the redesigned prototype with subsequent evaluation, testing, etc.; the redesign for quantity production, aimed at removing the weaknesses disclosed to date, and at the realization of a readily reproducible system of uniform and reliable characteristics; the actual production; storage; marketing; and finally the maintenance of the resulting system in actual mass use.

At several stages in the realization of the desired system, careful analysis and evaluation of the system are absolutely necessary to disclose the characteristics of the systems, its utility, weaknesses, advantages, disadvantages, feasibility, reliability, and the like. Such analyses and evaluations commonly require the services of people of many talents. It has been found that mature mathematicians of sound judgment widely versed in the physical, economic, and statistical sciences are particularly well suited for this type of work.

All sorts of talents are made use of in such programs. In the pure research stage there may be no specific motive other than inherent curiosity, the search for new knowledge and understanding. Even later this stage may involve an organized program of search. It is in these stages that the true university research methods of mathematics, physics, and chemistry should be expected to predominate. Later when more of a specific phenomenon is known there comes a stage when the problems of utilizing the discoveries become of real interest. This stage introduces many real challenges and commonly carries over into a multitude of problems which fall naturally into the engineering research type of activity. The gap between the discovery of a new physical phenomenon and the actual utilization of the discovery may be a long and difficult one. From this, one works into the formal development stage with all its trials and tribulations, tests, failures, etc. Eventually a prototype is evolved which can be made to operate with some sort of reliability. From the experiences with such prototypes there is evolved a design suitable for mass production and with some hope of achieving a uniformly dependable production product. Not the least, of course, are the problems of marketing the system as produced and its subsequent successful operation and maintenance by people with little real knowledge of the system.

Various Talents Required

Each of these steps leading to a satisfactory system requires various types of talents. Experts in the physical sciences are apt to predominate in the research and applied research stages, while the research engineer is apt to play a dominant role in the applied research and development stages, the more practical type of engineer playing the more dominant role in the development, prototype, design and production stages.

The research mathematician may be expected to find his principal efforts in the pure, and to some extent, in the applied research stages. The applied mathematician may in general find his services most needed beginning in the research stage, but perhaps with much effort being expended in the applied research, design and development stages. His services

may be used in the analysis and evaluation of the system at various stages in the process.

A mathematician trained to participate in a program leading to improved systems, such as referred to above, may be required to work in many fields, and at times his work may be far removed from the type of research which academic mathematicians in this country commonly think of as mathematical research. But nevertheless the services of such a mathematician in industry and government can be of great value. He can bring to bear a tremendous background of knowledge and techniques in the arts of calculation, and of analysis. The more he knows of numerical methods and the limitations and potentials of computing engines; the basic fields of applied mathematics (electrodynamics, electronics, elasticity, dynamics and statics, thermodynamics, heat conduction, etc.); the principal fields of analysis (ordinary and partial differential and integral equations, calculus of variations, real and complex analysis, analysis in general); the great fields of geometry (differential geometry, tensor analysis, and related fields); the mathematical theory and practice of probability and statistics (including a basic knowledge of information theory); the structure of modern abstract algebra (including some number theory); and modern mathematical physics (both classical and quantum); then more useful he is apt to be. Obviously, such a background requires not only a good mathematical education, but requires, in addition, considerable study of some of the more theoretical branches of engineering and physics, some of which can be acquired in the undergraduate school, some later.

Such a background is in many respects a much more formidable one to acquire than one leading to a Ph.D. degree in some specific branch of mathematics. But it is such a background that a real applied mathematician should acquire somehow. Our universities must recognize such professions and provide for their training with the full realization that such talent will be normally expected to seek employment in our great industries rather than follow a career of teaching and academic research.

It is sometimes thought difficult to distinguish between the training for such a mathematician, as I have described, and that for a physicist or research engineer. Actually the difference is fairly easy to delineate. The physicist, engineer and applied mathematician do have much in common so far as their training is concerned.

Fundamental Distinction

Perhaps the fundamental distinction between the type of graduate mathematical training and the corresponding type of training in physics is in the development of an understanding and an appreciation for the structure of the analytical work—the mathematics; whereas the emphasis in physics (even theoretical physics) is on the physical development of the theories. In border fields either mode of approach alone is apt to leave one rather much in the dark as to the underlying structure of the reasoning used, unless specific attention is made to develop the theme from both points of view.

The training for the physicist is concerned primarily with the preparation for a life of search leading to a better understanding of nuclear or sub-nuclear forces, to the development of new theories which fit all the facts, and permit accurate predictions of experiments, theories which reveal a broad quantitative understanding of a field of physics. The training for the engineer (especially one trained for advanced work and research) is designed to prepare the student primarily for work which will result in the development and realization of new practices, new materials, new methods of design, better understandings of vibration, fatigue. Such training should fit one for work intermediate between the work of the pure scientist and the so-called industrial engineer; (the training for the industrial en-

gineer is aimed principally at the development of fundamental knowledge necessary to carry out designs, perhaps based on more traditional technology). On the other hand the training for the mathematician is concerned primarily with the development and structures of the various essential disciplines of mathematics. Thus a deep understanding of the underlying structure of abstract algebra (including group theory, invariant theory) will serve as an unusually valuable background for the understanding of various branches of physics; a well rounded foundation in geometry will help grasp and interpret many applications to modern physics, which as often written appear as specific examples or applications, with the results that the basic logical structure involved may not be understood (often not even by the writer of the physics). For example, a good background of the algebra and differential geometry underlying the theory of tensors, spinors, and the representation of groups, aids very materially in the understanding and knitting together of many current publications and efforts in the modern theories of the structure of physics.

In planning curricula for mathematics of the type described it should be realized that techniques change so rapidly that it serves little purpose to spend too much time on specific details of some specialized branch (e.g., quality control vs. a broad foundation in probability and statistics), rather the effort should be placed on the fundamental structure of the subject matter.

The deeply trained mature mathematician of judgment working in the fields of physical science, and of engineering, can often bring to bear a perspective, an overall approach, a generalization or common architecture which can contribute much to the understanding, explanation, and the knitting together of a large class of phenomena. Such a contribution when it can be made is often of great significance. He by necessity must cross many fields and hence must have a broad training in the foundations of a variety of topics.

Trend in Engineering Education

There is a trend in engineering education which we should review here in order to give a better perspective to my main theme.

Engineering training in some of its more difficult and advanced phases has much in common with the training for a career in physics. So much must be learned for the various types of engineering work that four or five years of college is insufficient to give the broad scientific and fundamental knowledge needed. Six and seven years of schooling on the professional level is often necessary, and this type of training is not necessarily the same in spirit and practice as the traditional seven years of undergraduate and graduate work leading to the Ph.D. degree.

The mathematician has long known that he must spend seven or eight years of college work in order to lay a broad background for a teaching or research career in mathematics. Physicists and chemists have some to know this, too. The engineers are feeling this need in some quarters now.

It is my contention that professional schools beyond the usual four years of college or university must recognize that there are two distinct approaches and perhaps goals in any training for the fifth to seventh years—the usual graduate school period. One approach may be termed that of the professional school—leading to some sort of advanced professional degree or certificate; the other, the more traditional graduate school approach—leading to the Ph.D. degree of comprehensive standards.

I claim that in most branches of engineering and physical science—and in mathematics—that this division of effort and emphasis is a healthy and desirable one.

We should design the fifth to seventh year mathematical offerings towards:

(a) a professional career with appropriate training and experience, leading to an appropriate degree or certificate.

or

(b) a traditional graduate school training leading to the Ph.D. degree, with the principal emphasis upon training for research in a highly specialized atmosphere.

For example, in mathematics, there are gifted students who are really not cut out for careers in pure research and teaching, but who are really gifted in a way which will make them admirably suited for careers in industry. I refer to careers where a highly technical training in the mathematical and physical sciences is necessary for the work, but where the special talents and interests of such individuals are such that they can contribute much more of benefit in industry than in pure research and teaching. Students competent to follow either of these types of advanced work are generally of superior talents and potential abilities.

A broad training in mathematics, engineering, and science will be of more value to many professional students than a more narrow training and specialization into some highly refined branch of mathematical research. Both types should be encouraged, but we should be very sure that in shepherding talent toward purely mathematical research we do not forget the other types of professional mathematicians.

Our colleges in engineering and physics are already doing much along the lines I have been talking about under the broader category. We in mathematics should do more of this type of work too, in cooperation with other fields. Well-trained mathematicians, with some background in the physical and engineering sciences, have much to offer.

In other words, I am advocating strongly a "new look" at the philosophy of educating mathematicians in our mathematics departments.

True, some institutions are doing striking things along these lines, but I say too many are *not*—as yet.

Conclusion

To conclude, it appears beyond doubt that much more attention must be paid to the training of mathematicians for careers in industry than has been traditional in this country.

A professional school of applied mathematics not necessarily directed toward pure mathematical research but directed toward a wide and broader field of training, which will prepare the student for a very wide variety of useful professional service in almost any branch of engineering, science, economics, etc., should be provided. This training may or may not lead to the Ph.D. degree, but should lead to some form of higher professional degree or certificate.

In carrying forward this program it is furthermore urged that a continuation of the traditional training for the Ph.D. degree in research and teaching of mathematics must be encouraged. This should be done in the atmosphere of the true graduate school in the broadest sense with emphasis toward research.

It is the responsibility of mathematics departments to sponsor both types of training; and often the first type when only little of the second type can be done.

And finally, may I emphasize the importance of crossing subject lines; make the professional course with the major in mathematics one overlapping into many fields. Research and development in the world is not "topology" alone, or "numerical methods," or organic chemistry, or philosophy. It is a blending of any and all known disciplines into a homogeneous system designed to end up in something of better use to all men.

Train mathematicians for service and see that their sights are kept broad, with real breadth of vision.

Cracking the Creative Nut

By DONALD S. PEARSON

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Industry today is clamoring for engineers who not only have the ability to solve related problems in various fields but especially those who are able to recognize problems and *do* something about them. This need is destined to become even greater and greater.

A close look at the senior or graduate student in our engineering colleges quickly reveals a weakness in his ability to use the physical principles, and mathematical laws relating such principles learned in his formalized courses. To solve a problem based on methods covered in a text is one thing, but to apply the methods learned from several sources to new and outside problems, either of his own choosing or those presented to him, is an entirely different situation.

Recognizing this as a problem requiring educational attention, I should like to relate briefly how I approached it. At the outset, my interest and background is largely the result of participation with industry as a staff member in several Creative Engineering Seminars, and my activity as an electrical design engineer and teacher.

In the spring semester, 1955, a course entitled Creative Methods was offered by the Electrical Engineering Department to senior and graduate students for a maximum of three credits. The course was divided into a one hour recitation and a two to three hour laboratory each week.

The one hour recitation period served to establish a background in "Applied Imagination" based on the text of the same name by A. F. Osborn. I found assimilation of the text rapid and discussions indicated that the students found it interesting from a psychological and philosophical viewpoint, and diversionary from the usual engineering course. Supplemental to the text, mimeographed class notes, outlines and other practices together with a bibliography were distributed at the appropriate time. Selected reports were assigned and discussed in class. Responsibility was placed on the student to report on current articles and maintain an up-to-date bibliography. Along with oral quizzing, these factors were taken into account in grading. It might also be added that other bases for grading were his participation in the group as a member and leader, the quantity and quality of his creative effort as evidenced by his reports, and a final examination.

The philosophy that he could be trained to use his own talent more productively by systematic practice of the principles and procedures set forth, led at once to these practices in the laboratory session. The goal of each man was at least one creation as evidenced by a report including drawings, sketches or models. There was no limit placed on the number of creations but it was suggested that these be restricted to his own field of endeavor. Creating has been defined as " a combination of things or attributes that is new or different to him or to those about him."

One of the striking points brought out in the first laboratory period was the great difficulty encountered by the seniors in finding or recognizing a problem. However, two graduates, employed full-time in a research organization, had little difficulty in this respect. Here was a problem facing the group: i.e., *"what are the problems and where are they found?"*

In order to gain practice in group techniques, no restrictions were placed on the types of problems in this early stage of the course. A "brainstorm" session revealed a number of problems for group consideration such as "anti-upset device for farm tractors," "automatic automobile decelerator," "automatic safety brakes for holding cars or trucks on hills" and many others of this nature. Each member then selected, with the approval of the instructor, a problem of his own choosing or one revealed in the "brainstorm" session. He was allowed as much group help as he could get to assist him in solving this problem in a scheduled time limit. He was to demonstrate its effectiveness, by report.

During the preliminary six-week period, a technical problem was assigned a week in advance of its approach by the group. Each member was asked to think about its solution during the week. As a thinking prop he was asked to keep a sheet of paper in his notebook in which to write any and all problems relating to electrical engineering as a result of this course or any other experience. During the ninth week he was asked to make a selection from the list just mentioned and report the title to me for a final project or in lieu of this I would make a problem assignment.

It was not the purpose of this article to make a detailed evaluation of the results. However, briefly there have resulted several patent applications and disclosures and it might be of interest to mention at least one of these. This was a "constant current direct coupled amplifier" capable of a 0–100 k.c. response using two tubes (one bottle) with a voltage gain of 1300. This amplifier uses a single 250-volt supply with no negative supply voltage and has a current drain of less than 15 ma.

Conclusion

The following comments concerning the value of the course have come from the students;

1. He has acquired practice in applying theory and gaining confidence in his ability to solve problems.
2. He has acquired a technique for solving problems which applies to individuals as well as groups.
3. He has learned to cooperate with others and respect their points of view.
4. He has learned to evaluate by approximation before making decisions.
5. Stimulation of his ideas has in turn stimulated others.
6. The sense of accomplishment is an incentive to bigger and better things.

As for the instructor, it might be said that;

1. The course is a challenge to teaching and in equal measure an inspiration.
2. The important thing about progress is change and an open mind is imperative.
3. Flexibility is the keynote in tailoring the course to the needs of the group.

Special Notice

The Proceedings of the Eighth Annual Conference on the Administration of Research are available from the New York University Press, New York City. Pp. 108. Graphs, figures. Paper bound. $4.00. Included in the volume are talks on appraising and rewarding the researcher's output (merit raises), management in the research laboratory, communication problems in a research laboratory, physical facilities for research, and basic research in an applied research laboratory.

The Role of the Colleges in Nuclear Engineering Education*

By G. A. HAWKINS

Dean of Engineering, Purdue University

I. Introduction

The sudden advent of atomic power in war and peace has created some confusion in the minds of many educators and industrialists as to the immediate and future needs in the education of engineers for the new nuclear industry. In this presentation some views as to the requirements, and the responsibilities of the colleges and universities to fill inadequacies, will be offered for your consideration.

A recent opinion poll taken by the ASEE Atomic Energy Education Committee indicates that engineering educators are vitally interested in obtaining as much information as possible on the subject. The committee prepared a questionnaire stating that in order to formulate a program of maximum value, they would appreciate an indication of which of the following plans would be of greatest benefit to the institution:

A. "Having an individual who is an authority in the field and who understands the problems of engineering education visit your institution to discuss atomic energy education with interested members of the faculty, and to suggest procedures that might be used."

B. "Having a team composed of authorities visit your institution to discuss the problems with interested members of the faculty."

C. "Having a report prepared and distributed describing various procedures that could be utilized in incorporating nuclear science into the engineering curricula."

D. "Sending representatives of your faculty at your expense to regional conferences devoted to the subject."

Replies were received from 138 of the 147 institutions contacted. The majority requested Plan C as the first choice, and Plan A as the second choice. Plans B and D lagged far behind C and A from an interest standpoint.

In response to the need expressed by the educators, the Committee is now actively engaged in compiling data for use in the preparation of a report based on Plan C.

Information gathered thus far tends to indicate that the need for engineers in the nuclear industry may be grouped into three classes.

1. The first is an immediate requirement for engineers to work in:

   a. AEC Contractors' facilities.
   b. Colleges and universities to aid in planning suitable educational programs.
   c. Those industries involved in the design of nuclear power plants and related equipment.

Many of the engineers entering the field will need on-the-job training to aid them in developing the necessary background.

2. The second is a requirement for the education of students who have the necessary background and are interested in

* Presented at the Annual Meeting of ASEE, Conference on Atomic Energy Education, Penn State University, June 22, 1955.

entering the field in functions such as design, development, and research.

3. The third is a future need to educate engineers for other functions such as maintenance, operations, sales, etc. This requirement will become more pressing as the industry expands.

II. Educational Programs.

The educational programs which may assist in relieving the present pressing need for engineers and for the future requirements may be classified in the following manner:

A. Undergraduate Engineering Education.

An undergraduate educational program for the engineer based on the ideas advocated in the report of the ASEE Committee on The Evaluation of Engineering Education appears to be well suited for students interested in entering the nuclear industry. By means of a strong core of the physical sciences and the engineering sciences together with sufficient flexibility in electives, the student may begin to prepare himself for future work in the area of nuclear energy. Many of the existing professional programs do not afford enough flexibility to enable the student to obtain the desirable physics background for work in the atomic energy fields.

The need for an educational introduction to the nuclear field may be filled by:

a. Establishment of curricula in nuclear engineering. This plan has already been placed in operation at the North Carolina State College at Raleigh, North Carolina.

The program contains more basic science and engineering science courses, and less material of a specialized nature than is now incorporated in many engineering curricula.

b. Providing flexibility in existing programs.

A sufficient number of courses could be introduced in place of technical electives to give the student the necessary background for nuclear work, if greater flexibility could be provided in the curriculum.

c. Introduction of nuclear material in existing required courses.

Some introductory nuclear material could be introduced into existing required courses in the undergraduate engineering programs. This would allow all of the students to become acquainted with the subject.

At the present time only students who have an aptitude for research, development, and design should be encouraged to take such a special curriculum or specialized elective courses. Only after the industry has grown and need arises for engineers in functions involving construction, operations, sales, etc. should other students be advised to carry courses in specialized subject matter. The colleges and universities engaged in engineering education will have to provide the suitable academic atmosphere and instruction to enable students interested in atomic energy to enter the industry especially qualified for work in the field.

B. Graduate Engineering Education.

The short and long term need for engineers having advanced training is definitely a responsibility of the colleges and universities. Opportunities should be afforded graduate students to undertake academic programs and to do research in preparation for future work in the nuclear industry. Many institutions are already offering study plans in the nuclear engineering area.

A number of educational institutions and the National Laboratories are cooperating to enable graduate students to work on their theses in the laboratories after having completed course work at their respective college or university.

C. Adult Education.

The universities and colleges may contribute significantly to the development of engineers who did not have the necessary courses to study as students, but who de-

sire to enter the nuclear industry. These practicing engineers may be divided into the following groups for purposes of discussing possible programs:

1. Practicing engineers employed in various industries who desire to enter the nuclear industry.
2. Recent engineering school graduates interested in entering the nuclear field.
3. International students.

The U. S. Government has established a policy of encouraging international engineers to study nuclear subjects in this country.

The colleges and universities and the governmental laboratories are handling the demands for the education of their groups at the present time, but in order to keep pace with the developments additional opportunities must be made available. Some of the methods now in use follow:

Colleges and Universities.

a. By offering both day and night regular term courses in physics and nuclear science.

b. By concentrated periods of instruction at the institution for periods ranging from several weeks to full terms.

c. By concentrated short courses of only several weeks duration.

d. By correspondence work.

Governmental Laboratories.

a. Special technical programs of varying lengths.

Laboratories such as the Argonne and Oak Ridge installations have established specialized programs of study of varying lengths of time. An example is the Oak Ridge Institute of Reactor Technology.

The Argonne National Laboratory is now offering a program of study for international students.

b. Special courses and lectures for employees.

Many of the national laboratories and AEC contractors offer special courses for their employees and others in order to enable interested persons to expand their knowledge in this field.

III. Research.

If a graduate program is to be established, then research in the area is a vital necessity. Research activities in the field of atomic power may be carried out by a university in a number of ways, some of which are listed as follows:

1. Basic research.

The National Laboratories have encouraged the colleges and universities to undertake basic research in the field. Many of the problems can be studied without a reactor. Support for this type of research may be obtained through funds from industry and governmental sources. Some universities are also contributing funds to encourage members of their staff to undertake research in the area of nuclear engineering.

There are also a number of worth-while problems, but less basic, which are of interest to individual staff members. This research can be carried out under similar arrangements.

2. Cooperative research programs with National Laboratories where the student completes his research at one of the Laboratories after the formal course work has been finished at an educational institution.

IV. Staff.

In order to offer course work and to conduct research at an educational institution, it is necessary to have members of the staff thoroughly familiar with the subject. Since it will not be possible to recruit enough qualified persons from the nuclear industry for teaching purposes, it will be necessary to encourage present staff members to take an active part in the development of the program. Education of the staff in this area may be accomplished in a number of ways, some of which follow:

1. Leave of absence for work at a National Laboratory.

2. Leave of absence for work in an industry closely allied with the nuclear power field.

3. Leave of absence for study at institutions having established courses.

4. Cooperative consulting arrangements with National Laboratories and industries engaged in developments in the field.

5. Attendance at short courses and conferences.

6. Reduction of time devoted to normal academic work to provide time for concentrated self-study of the subject.

7. Conferences and seminars conducted by qualified authorities in the field held on the institutions' campuses.

8. Appointment of qualified visiting professors for a period of one to two terms.

V. Conclusions.

From all indications the nuclear industry will expand at a very rapid rate. This will create a demand for engineers professionally qualified in the area. In order to fill this need, the colleges and universities must assume their share of the responsibility to provide engineers to work in the nuclear industry.

College Notes

Dean Edward R. Stapley of **Oklahoma A. & M. College** has retired and been named dean emeritus of A. & M.'s Oklahoma Institute of Technology and professor emeritus of civil engineering.

Dr. Newman A. Hall has been named to head the Graduate Division of the **New York University** College of Engineering. Dr. Hall will serve as assistant dean and professor of mechanical engineering. He is also chairman of the Graduate Division of the ASEE.

Frederick E. Terman, dean of the Stanford School of Engineering, has been appointed provost of **Stanford University**. He will continue as dean of engineering, also.

Chester A. Arents, coordinator of research and professor of mechanical engineering at Illinois Institute of Technology, has been named dean of the college of engineering at **West Virginia University** to replace the retiring dean, Dr. **Roland P. Davis.**

Physics Is Not Engineering*

By R. J. SEEGER

Assistant Director, National Science Foundation

When I began teaching general physics I was assigned responsibility for the part on electricity and magnetism. In attempting to correlate the lecture and recitation material with the laboratory manual I found myself beginning the course with familiar electric currents (instead of electrostatics) and then utilizing a phenomenological concept like conductance for parallel connections (instead of resistance). One day I was telling a colleague, a professor of electrical engineering, about my teaching problem and my unorthodox solution. To my surprise I learned that I had been using the customary approach of electrical engineering. Of course, I suppose that I should have suspected it inasmuch as the laboratory text had been written by a professor of physics with an electrical engineering background. I was disturbed. Was I really teaching physics or electrical engineering? This was my first introduction to the no man's land between physics and engineering. As I now look over that same territory, however, regardless of similar pedagogical techniques, I am convinced that "physics is not engineering."

The engineer is certainly concerned primarily with creative design. He makes use of known information, such as the availability of materials, their cost, and safety requirements. Unfortunately, owing to insufficiency of data or time he is often compelled to make a decision despite many facts still being unknown. The physicist, on the other hand, is engaged primarily in creative research. He attempts to understand phenomena and to determine their underlying principles. He, too, starts with certain known observations and familiar concepts and then imagines a broader picture to include also the unknown. His problem, therefore, is essentially a theoretical one; it lacks the critical urgency of practicality. The physicist is not time bound. In this important sense physics is not engineering.

Most of us I believe would have subscribed to this distinction between the physicist and the engineer a decade ago. The outline, however, has recently become somewhat hazy owing to the innovation of the term "engineering science." One may emphasize the adjective engineering, in which case engineering science is essentially a body of scientific knowledge useful for solving practical problems. On the other hand, one may stress the noun science so that engineering science may be regarded as genuinely basic science involving phenomena relating to engineering problems. In this sense, of course, physics itself might well be designated an engineering science. The historical evolution of much of engineering from physics justifies this point of view. In this connection I am reminded of Professor E. Weber's definition of engineering science as those parts of chemistry, mathematics and physics that are no longer of primary interest to chemists, mathematicians, and physicists. My only criticism of this definition is that it presupposes less interest nowadays in certain phenomena by physicists. The fact is, however, that there are more physicists interested in these very phenomena today than ever before. At the same time, it is true, there are many

*Invited address at the Winter General Meeting of the American Institute of Electrical Engineers in New York, 1955.

more physicists altogether so that the absolute increase is concealed in the relative decrease. Thus we find today that the physicists have a genuine research interest in physical mechanics, corresponding to that of engineers in engineering mechanics, in physical thermodynamics corresponding to engineering thermodynamics (from the viewpoint of the chemical engineer and of the mechanical engineer), in physical electrodynamics corresponding to engineering electromagnetism, in physical electronics corresponding to engineering electronics. As a matter of fact these different viewpoints of the same subject might result in a false dichotomy. The viewpoints are certainly distinctive, but the object is common. From this standpoint I view with some concern the present attempt to draw a sharp line between so-called engineering sciences and basic sciences. Whereas I realize that the physics viewpoint is not the engineering viewpoint, I am confused over the concept of the engineering scientist. Is he a scientist or an engineer? Or is this merely a way of calling attention to the increasing scientific basis for engineering? Perhaps we can dismiss this semantic difficulty with Juliet's reminder:

"What's in a name? that which we call a rose
By any other name would smell as sweet."

Let us turn now to the problem for discussion today, namely, the teaching of electricity and magnetism in general physics. The guiding light, I believe, is a presentation of interrelated principles and concepts from a truly modern viewpoint. For example, the children of yesterday played with pith balls and magnets, but the children of today, like my son, John Mark, age six, play with toy transformers. Hence I suggest that we must begin our instruction not historically but rather systematically from today's vantage point. In order to understand electricity, however, we need to look first at mechanics.

Evolutionary in its Development

Popular opinion notwithstanding, physics is essentially evolutionary in its development, not revolutionary. Science, moreover, cannot be divided into separate and unrelated sections. Thus all physics is rooted in mechanics with its great conservation laws of momentum and energy or mass. True, these generalizations developed out of Newton's laws of motion and were later extended to phenomena of thermodynamics and electrodynamics with the resultant widespread philosophy of mechanism. If we are to view electrodynamics today, we must do so from the background of mechanics. In this connection, however, it is not so important that we see superficial similarities between Newton's law of gravitation force and Coulomb's laws of electric force and of magnetic force. Rather we should realize at the start that we are dealing in electrodynamics within an entirely different type of force from the central force encountered in mechanics, namely, the type of force experienced by a small magnet near a moving electrically charged body, a force that acts not along the line from the magnet to the body but at right angles to it. Moreover, the very intensity of the force depends not just upon a scalar quantity like the distance apart, but upon a vector quantity like the velocity of the body. In order truly to appreciate these differences, however, it will be necessary to understand thoroughly the common mechanics background of physics.

Electrodynamics, we soon realize, has its theoretical description based largely on the concept of a field of force, which certainly ranks as the most important concept introduced in physics since the advent of Newtonian mechanics and as the culmination of the classical method. For example, if we look at a bar magnet, we see a rectangular piece of iron carrying no electric current. At the same time, if we look at a copper helix carrying an electric current we observe a solenoid. On the surface these two objects appear to have nothing in common. Yet the phenomena

are indistinguishable in their external electromagnetic effects of attraction and repulsion. The field which describes these phenomena takes on a greater physical reality than the sources of the phenomena themselves. Therefore, if we wish to understand the phenomena, we should begin with the field as a model, not with electric charges, not with magnetic poles, not even with elementary particles. Strangely enough, to understand the properties of such materials we must study the field in the empty space between them.

Michael Faraday is remembered for his persistent investigation of electric and magnetic phenomena. The mathematical description of them is due to Clerk Maxwell. The Maxwell equations for a vacuum describe the history of the field, as Newton's equations give the history of particles. They form a pattern for a new type of physical law which holds throughout all space and not merely at those points where matter is present as in mechanics. Thus we naturally begin with the simplest of fields, the electrostatic field about an electrically charged body, and then we consider the static electric field in a conductor carrying a steady electric current. Such a conductor, of course, has also a magnetic field, which is the next topic to be studied. We are reminded historically that it was H. C. Oersted who first noted the magnetic effect of an electric current, that it was A. M. Ampère who then conceived of elementary electric currents accounting for macroscopic magnetic effects, and finally, that it was H. A. Rowland who showed experimentally that a convected electric charge does, indeed, produce a magnetic effect. From the study of steady fields one investigates next changing electromagnetic fields, which produce displacement currents with their associated electromagnetic waves. Here we find ourselves considering radiation, both the long-range coherent waves in wires and the short incoherent waves of dipole radiation. Certainly at this point modern students must be made to realize the significance of the constancy of the velocity of light in a vacuum, which fixes a limit on the effects of radiation and necessitates a relativistic point of view in order to establish the invariant properties of these phenomena.

Having discussed Maxwell's equations for free space, we consider next the electric and magnetic behavior of material bodies, namely, electrical conduction, first in a vacuum and then in metals, dielectrics with polarization, electrical origin of magnetic properties, including poles in magnetic materials resulting from electric currents, and finally, electromagnetic waves in material media, with their properties of reflection, refraction, dispersion, scattering, interference, diffraction, and heat radiation. In this way we view optics as a branch of electromagnetism. Naturally we are concerned primarily with physical optics and regard geometrical optics essentially as a physical approximation valid only under certain geometrical conditions. In considering optics, however, we must consider the momentum of electromagnetic radiation. Here we are confronted with another limitation of theoretical investigations, namely, the impossibility of measuring with unlimited precision simultaneously the momentum and the position of a particle. Another fundamental constant of nature, namely, Planck's constant, tantalizes us here with its universality.

In this view of general physics, mechanics with its particle concept naturally represents the first phase. Electromagnetism, with its all important field concept, is the second phase. Modern physics as a third phase, strictly speaking, begins with the theoretical significance of the limitations of measurements due to the universal character of the velocity of light and of the quantum of action. It may be recalled that Lord Kelvin at the close of the 19th century referred to these two experimental facts as the only clouds upon the broad horizon of classical physics, clouds that became respectively the relativity theory and the quantum theory of the 20th century.

What is Physics?

So much for the content and sequence of a beginning physics course in electricity and magnetism, which I regard as being necessarily the same for any scientific introduction, whether for an engineer or for a scientist or even for a humanist. A different spirit of inquiry, however, may be used in each approach. This necessarily involves the question, "what is physics?"

We all agree that physics is a basic science. But what is a science? Do we mean the same thing when we say domestic science? political science? divine science? Christian Science? We might take the etymological notion that science is knowledge, with the reservation that we mean here systematized knowledge in the sense of German *wissenschaften*, which covers all knowledge. On this basis in medieval times science included both secular philosophy and revealed knowledge. According to the modern positivistic viewpoint, however, science is thus identified with philosophy. "The question is," said Alice, "whether you can make words mean so many different things."

What is science? May I suggest as a starting point that we regard science as the cumulative result of the use of the scientific method. In this connection I am quite aware of Dr. Conant's objection in *Science and Common Sense:* "There is no such thing as *the* scientific method." I submit, however, that his conclusion follows from his own restrictive definition. It is a matter of taste whether one believes that there are essentially different methods, or one general method with different degrees of success dependent on materials investigated, that is, physical, biological, social. To me *the* scientific method involves essentially questioning, with the ever present possibility that stupid questions can result only in stupid answers. One begins, however, by asking questions of nature. The answers are the observed facts. One looks for related factors among them and then tries to synthesize all with a factitious theory. From this vantage point one asks new questions and so the cycle repeats without end. One always begins with phenomena and then subjects theoretical conclusions to two criteria: (1) comparison with the phenomena themselves, and (2) review under the testing light of common expert opinion. It is important to realize that science is neither essentially empirical nor solely rational. It is not simply deductive or simply inductive, but rather an interplaying combination of these two procedures. The theory resulting from the use of the scientific method is meritorious in so far as it describes what is known and predicts what is unknown.

In all this we note the major role of the scientist himself. In view of the fact that the scientific method is really nothing more than what is used by the scientist, we find the scientist continually selecting—first, facts, then factors, and finally theory itself. Throughout the entire investigation he is using creative imagination. What is most important is not his sight but his insight, not so much the things he sees as what he sees in things. Thus the laboratory is like an art studio, like a kindergarten. In short, physics is fun. Whatever other by-products of the teaching of physics may exist, unless the student is enjoying the course, it is a failure. This one criterion I would propose as a measure par excellence of the effectiveness of physics teaching: is it fun?

In this connection I believe it is important that we get historical perspective by seeing how other persons discovered nature's secrets in the past, and that we get philosophical breadth by appreciating the limitations of our own theoretical views. Above all, the student should be shown the vista of relations among apparently unrelated phenomena such as a magnetic stone found in Asia Minor, an amber pebble picked up in the Baltic Sea, and a frog being used for biological demonstration in Italy. The student should be warned at all times of the danger of greater respect for the expressed word than for the

unexpressed thing, for which it stands symbolically. The thing is all important!

The student should even be encouraged to challenge the accepted order of things, so-called common sense. It will be recalled that in investigating the conduction of electricity in solids the 18th century was faced with a dilemma between two theories, the one-fluid theory and the two-fluid theory. On the other hand, in investigating the conduction of electricity in liquids, the 19th century faced another dilemma as to whether electricity is inherently continuous or atomistic. No one bothered, therefore, with the conduction of electricity in gases, which was regarded as just another instance of conduction. Hence Crooke's tubes at the close of the century were only playthings of science. Yet it was in the investigation of the conduction of electricity through gases that we found the answers both to the dilemma of the 18th century and to that of the 19th century, namely, the discovery of the electron.

Summary

In summary, even though engineering *must* be taught as an application of principles to practical problems, and even though science *can* be taught as a body of principles themselves, I believe science *should* be taught necessarily as a curious scientist's probing method to understand natural phenomena. In this respect, certainly, physics is not engineering.

College Notes

The nuclear option of the Department of Chemical Engineering of the **Polytechnic Institute of Brooklyn** had its formal introduction when 12 senior undergraduates started taking the new courses during the 1955–56 academic year. These 12 students have already taken the necessary basic courses in nuclear and chemical physics last year in preparation for the option. Although a minor specialization in the chemical engineering curriculum, the nuclear option will give chemical engineers a strong foundation in both the theory and technology of the processes involved in the production of power through nuclear energy.

In addition to the undergraduate program, Polytechnic's graduate school for the first time is offering courses in the field this fall. These basic courses are open to part-time students without previous experience or prerequisites in the nuclear field except an academic background in chemical engineering.

A teaching professorship in chemical engineering, believed to be the first industrially-sponsored university chair specifically limited to undergraduate instruction, will be established at **Cornell University** with funds given by Socony Mobil Oil Company, Inc.

A nationally recognized chemical engineer, between the ages of 35 and 45 and with strong industrial experience, will be sought to fill the chair, which will be created in Cornell's School of Chemical and Metallurgical Engineering. In accordance with the agreement between the university and Socony Mobil, the professor will be encouraged to consult with industries served by chemical engineers. This is intended to help keep his teaching in close relationship to industrial problems and trends.

The agreement provides that Cornell has "complete freedom to select the professor and determine the manner in which teaching shall be conducted." Socony Mobil will give $60,000 to underwrite the professorship for an initial five-year period. In addition to the professor's salary, the fund will cover travel and other expenses related to the chair.

Ways to Increase Prestige and Improve Status of the Good Teacher*

By LEE H. JOHNSON

Dean, College of Engineering, Tulane University

(For the subcommittee of the Committee on Recognition and Incentives for Good Teaching)

This discussion springs from the work of a subcommittee of the Committee on Recognition and Incentives for Good Teaching. Its membership has consisted of Professor R. P. Hoelscher, University of Illinois, Professor Clyde R. Nichols, Purdue University, and Lee H. Johnson, Tulane University. All members of the Committee have contributed to the ideas which are expressed here.

The subject for discussion is rather difficult because it is hard, if not impossible, to find a definition of a good teacher to which all would subscribe. Different definitions lead to different approaches to the subject. Consequently it will be assumed for the moment that everyone will agree that good teaching is recognizable and the discussion will begin with ways to increase prestige and improve the status of teaching.

There is an old saying that "all roads lead to Rome." An over-simplification of the answer to our question might be paraphrased to say that "all ways of increasing prestige and improving status lead to recognition and reward." Recognition and reward are not necessarily two distinct things in themselves for although recognition of one sort may lead to reward in terms of promotion and increased income, recognition of another sort may in itself constitute a reward. Accordingly no attempt will be made to separate these in our discussion.

Let us re-phrase the subject for discussion as "ways to obtain recognition and reward for good teaching." Certainly nothing shall be forthcoming if nothing is known of the work of a good teacher, so the question resolves itself into channels of communication. This matter of communication is of primary importance. As Mr. Richard W. Schmelzer, Chairman of the Committee on Recognition and Incentives for Good Teaching, recently wrote, "The crux of the problem is this: how can we assign a quantitative value to good teaching?" How can we bring to light tangible evidence of superior instruction?

There is definite belief that recognition and reward for research are greater than for teaching. If this is true, perhaps it is because the results of research are more immediately seen in the form of reports and publications and because research can be lucrative to an institution. These are rather tangible things which are easily communicated. The subcommittee has approached the matter of communications by classifying the various ways of communicating the work of a good teacher and outlines them as follows:

Institutional:

Reports of developments and achievements each year to the Department Head and the Dean.

Reports by the Dean to the President and the governing board.

Letters and other expressions from former students.

* Panel discussion at Annual Meeting of ASEE, Educational Methods Division, Penn State University, June 20, 1955.

Departmental and school conferences on the objectives and methods of teaching which will bring out good work already being done.

Appointment to a committee or a group to work with beginning instructors.

Professional Recognition:

Papers on educational methods at ASEE meetings.

Papers on educational methods at local engineering society meetings.

Local and national awards by professional groups, medals, certificates, prizes and such.

Text books and other publications.

Industrial Recognition:

Industrial consulting on educational or training problems. Perhaps this is a new field which has not been explored for the talents of the good teacher.

Public Recognition:

Television and radio programs on such subjects as the art of teaching, engineering as a creative profession, vignettes of college teaching and such.

Newspaper and magazine announcements of achievements and awards.

Local and national civic or industrial awards.

The foregoing list is not intended to be a complete statement of ways to bring recognition and reward. However, it does imply that something is being done which is worthy of recognition and reward. Just how much is being done? We have all heard many times that "It's hard to keep a good man down." If there are many, many outstanding teachers, creative in their thinking and stimulating and inspiring to their students, it is hard to believe that this forceful group would long remain submerged. Perhaps many of those who would have become great teachers have had their energy and thought diverted to research or administration. Perhaps, also, not enough attention has been focussed on the opportunities for research in teaching which would lead to achievements not easily overlooked by colleagues in research and administration. Certainly patterns in teaching seem to follow a rather restricted path and strongly resist change. It is understandable that materials of engineering and the physical and chemical forces of nature are easier to work with than habits and attitudes of human beings.

This suggests that one of the fundamental problems in increasing the prestige and improving the status of teaching is to make the profession acutely aware of the tremendous area in teaching which remains unexplored, to make it aware of the great opportunity for research and creative thinking within the classroom itself.

Examples

A few specific examples may serve to illustrate this idea sufficiently. Generation after generation of engineering students has been taught mechanics in the sequence of statics, dynamics, strength of materials, and hydraulics or fluid mechanics. Is this sacred, or would statics and strength of materials taught in sequence followed by dynamics and fluid mechanics as a second sequence be a better arrangement?

It has been said that courses such as statics or dynamics are set. The implication is that nothing can be done to change the way those courses are taught because the subject matter is rigid and unchanging. There is no argument possible about the correctness of the principles of static equilibrium or of Newton's Laws of motion in these courses. And so the entire emphasis is on a type of problem in which the conditions are completely specified and which has a unique answer. How many instructors in mechanics ever give problems in which each student would get a different answer? For example, one problem might be, "Time yourself in running from the ground floor to the third floor of a building and compute your horsepower." This involves techniques of

measurement and some choice on the part of students as well as the application of elementary principles of dynamics. Arguments between students who choose different methods of measurement or different conditions for obtaining data may well bring out other aspects of dynamics as well as of measurement.

Again, another problem might be, "Make a close estimate of the forces which keep the trunk lid of an automobile open. Outline carefully your approach to the problem and the methods used. Accompany your solution with a neat, dimensioned, free-hand sketch." This problem introduces a number of factors which must be considered by the professional engineer in practice while it requires the application of the principles for static equilibrium. Different methods of measurement will be used and different methods of supporting the trunk lid will be presented. Elements of report writing are inherent in drawing up the problem for submission to the instructor.

These are but two of thousands of examples to indicate opportunities for research in teaching. Perhaps the best way to increase the prestige and improve the status of teaching lies in a renewed attack upon time-worn ideas and hackneyed methods in teaching.

Special Notice

The National Science Teachers Association, 1201 Sixteenth St., N.W., Washington 6, D. C. announces the publication of the following booklets:

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The Prediction of Engineering Potentiality in High School Students*

By A. PEMBERTON JOHNSON

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The effectiveness, the cost, and the limitations of the prediction of engineering potentiality among high school students are of vital importance to our nation today. Apparently there is growing acceptance among parents, among high school students, and among secondary school teachers and administrators that *there is a shortage of engineers.* The heavy recruiting activity among engineering college seniors and juniors together with the high salaries being paid to them has become known in home and school. As you know, the aircraft industry has recently sought draft deferment for engineers. There has been concern recently that the Russians have outstripped us in military aeronautics. The Hoover Commission has recently recommended more spending for research and development to improve our scientific, engineering and production capabilities. In the March 1, 1954 *Newsweek,* Dr. Vannevar Bush, Head of the Carnegie Institution in Washington, D. C., was quoted as saying, "There seems to be no doubt that they, the Russians, are training more scientists than we are. They screen the country for talented kids more than we do. We are enamoured of the idea of mass education. Curiously, the Russians, despite Communism, extend special privilege to gifted youth, if we can believe anything we hear about them. We, on the other hand, still let too many gifted youths slip through our hands."

Recently Dr. M. L. Trytten of the National Research Council, Dr. Howard A. Meyerhoff of the Scientific Manpower Commission, and Mr. William T. Cavanaugh, Executive Secretary of the Engineering Manpower Commission, have pointed out the serious shortage of secondary school teachers who have the background to give sound and inspiring courses in science and mathematics. To improve the teaching of science and mathematics in secondary schools the Carnegie Corporation of New York has recently made a grant of $300,000 (announced early in June) to the American Association for the Advancement of Science. I am extremely hopeful that this grant will make possible a marked long-term improvement in the present situation.

In past days when we needed fewer scientists and engineers, the high school science and mathematics teachers often could make very satisfactory predictions of the engineering potentiality among their students. With the increased numbers applying for entrance to our engineering schools today, the practical limits in accommodating them, and the serious shortage of secondary school science and mathematics teachers, other means of identifying promising prospective engineering students are extremely important.

My friends in administrative positions in the engineering schools have pointed out many instances within their experience of the lack of dependence they could place on secondary school grades as indi-

* Presented at the Annual Meeting of ASEE, Aeronautical Division, Penn State University, June 22, 1955.

cators of potentiality for the study of engineering.

A few weeks ago, I was asked by the officials of one of our service academies to check the score of a man who was in college but who had applied to that academy for admission as a regular beginning student. This man was reported to have earned A grades both in high school and in college, but his aptitude score on the service academy entrance examination was in the lowest 2% of applicants, the majority of whom were high school seniors. As many of you know, grading standards vary widely, high school curricula vary a great deal, and the ability level of the students in high schools varies widely. You many not be aware, however, of the extraordinary range of the ability differences between schools.

I know of one school in which the ability level of all of their ablest seniors is in the lowest third of the ability level of seniors in another school. I am told that in certain studies which Educational Testing Service has made there are some high schools in which almost all of the 50 or more graduates are lower in level of ability than the *least* able graduate in certain other high schools. My conversations in the last few years with several engineering administrators suggest that there may be more than an ordinary proportion of applicants in recent years who have rather high ability as indicated by the better ability tests such as the College Entrance Examination Board Scholastic Aptitude Test (particularly the mathematical score) and the Pre-Engineering Ability Test but whose weak motivation to study engineering is markedly reduced by their experiences in the first semester or first term when they learn that they really have to study and apply themselves. We are all familiar with the long-standing situation that a number of able students, at least in certain high schools, have coasted through their last few years of work picking up atrocious study habits and then were not able to develop good ones quite soon enough to remain in engineering college.

We do know that the mathematical score on the College Board Scholastic Aptitude Test provides a most effective prediction of engineering college grades. It is, of course, merely an indication of ability. It provides no clue as to achievement or to motivation. We have no evidence that it is a measure of talent for making money, or of persuasive skill in dealing with people, or of the ability to invent useful things. In addition to scholastic ability, we would like to learn whether an applicant has learned to study or to discipline himself to do the day to day work which will be assigned to him in engineering school, for often an exceptionally able freshman has not learned these things. Achievement test scores are partial clues in this connection as are grades in secondary school.

If we set our standard as the earning of satisfactory grades in engineering school, we can predict this standard rather well using existing psychological tests together with rank in high school class. The present evidence suggests that for almost all engineering schools the Scholastic Aptitude Test mathematics score alone is a somewhat better predictor of engineering grades than is rank in high school graduating class. A marked improvement occurs when we combine the Scholastic Aptitude Test mathematics score with rank in high school class (See Figure 1). A slight improvement results when, in addition to these, the Intermediate or the Advanced Mathematics Test score of the College Board is added into the composite of the mathematics Scholastic Aptitude Test score and rank in high school class. Many engineering schools have concluded that the additional advantage from use of the achievement tests is not worth the additional cost in terms of time and money to the applicant.

It is becoming increasingly widely known that the verbal score on the Scholastic Aptitude Test can be an important aid in evaluating the qualifications of a

FIGURE 1

MATHEMATICS TEST SCORES COMBINED WITH HIGH SCHOOL GRADES GIVE EXCELLENT PREDICTION OF ENGINEERING COLLEGE GRADES

Portion of class on high school grades or test scores combined with high school grades	Approximate odds that a student will earn average or better first-term grades in engineering for:	
	High school grades used alone	SAT–M* scores combined with high school grades
Highest 10%	4 to 1	11 to 1
Highest 25%	3 to 1	5 to 1
Lowest 25%	1 to 3	1 to 5
Lowest 10%	1 to 4	1 to 11

* The Scholastic Aptitude Test (Mathematical Section) of the College Entrance Examination Board.

Data based upon a study by Dr. W. B. Schrader for 721 enrolled engineering freshmen tested in the Fall of 1948 at Carnegie Institute of Technology, Cornell University, Lehigh University, Rutgers University, and the University of Pennsylvania.

The weighted average correlation coefficient of high school grades against first-term engineering grades at these five institutions was .46. The weighted average correlation coefficient of SAT–M scores combined with high school grades against first-term engineering grades for these five institutions was .66.

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high school senior who is an applicant to an engineering college. In general, we are recommending the use of a combined scholastic aptitude test score along with consideration of rank in high school class for predicting success in engineering college. This combined score may be either an average of the mathematics and verbal scores of the College Board Scholastic Aptitude Test or a total obtained by doubling the mathematics score and adding the verbal score so that in effect twice as much weight is given to the mathematics score. In this way, if the verbal score is low it will serve to depress either the average or the total composite score. Ideally, of course, the proper weighting would be worked out at each institution, for I know one in the middle-Atlantic area in which the verbal score is a slightly better predictor than the mathematics score. As far as I know this institution is the only exception to the general rule of better prediction by the mathematics score.

For those institutions which receive achievement test scores as well as aptitude test scores the comparison of achievement test scores against corresponding aptitude test scores may give a rather good clue as to whether a particular man has performed up to the level of his ability as measured by the aptitude test. If your institution makes use of the College Board scores, you may wish to see the second edition of *College Board Scores—Their Interpretation and Use.* This booklet should be a great help in the use of College Board scores. A recent article by John R. Valley of ETS on use of the College Board tests at Case Institute of Technology entitled "The Case Against Freshman Flunk-Outs" appeared in the Winter 1955 issue of the *College Board Review.*

Some engineering colleges are faced with a problem of high school students dropping in and asking for an immediate evaluation of their potential for the study of engineering. In such situations, the Pre-Engineering Ability Test can be a

very useful substitute for the College Board test scores. Some comparative data are available for the direct comparison on an approximate basis of the Pre-Engineering Ability Test scores to College Board Scholastic Aptitude Test mathematics scores.

Neither the College Entrance Examination Board Scholastic Aptitude Test nor the Pre-Engineering Ability Test is available for use by secondary school principals, deans, or counselors. However, the Cooperative Intermediate Algebra Test which is available for secondary school use, and which takes only 40 minutes of testing time in addition to some time for handing out and collecting the test papers, answer sheets, and electrographic pencils, has been found to be a very effective predictor of grades at two institutions, Purdue and Cornell, when given to incoming new high school graduates.

The Cooperative General Achievement Tests—Test 2, a test of general proficiency in the field of natural science, which takes 40 minutes, and Test 3, a test of general proficiency in the field of mathematics, which takes 40 minutes—have been found in several schools to be effective predictors of grades. All of the tests which I have mentioned, however, are designed for use primarily at the high school senior or 12th grade level.

I believe it to be extremely important for the welfare of this nation that more and more engineers working with the secondary school people in their local school districts recognize the importance of the early identification of prospective engineering students particularly at the 7th to 9th grade levels, the particular level depending upon local conditions. In the high school systems where junior high schools are the rule, the differentiation in curriculum of the college-going engineering and science-oriented student as compared with other college-going students and as compared with the non-college going students begins to occur often in the 7th or 8th grade. It is critical at this stage that more mathematically and scientifically oriented students be identified so that they can be guided into the appropriate sequences of mathematics, science, and English to prepare them to meet the admissions requirements of most engineering colleges. Repeatedly we hear of able prospective engineering students who learn in the 10th or 11th grade that they should have begun back at the 8th or 9th grade level to take the sequence of mathematics, science, and English that they needed to enter the enginering college of their choice. The Cooperative Mathematics Test for grades 7, 8, and 9 and the Cooperative Science Test for grades 7, 8, and 9 though sometimes too difficult for average students in the 7th and 8th grade can prove quite useful as indicators of promise for the study of engineering or science. At this level, many schools use the traditional I.Q. or intelligence test which has considerable merit but which properly requires the use of some indication of the student's interest in the area of science rather than in humanities or the social studies as a satisfactory clue to his promise as an engineering or science student.

If you were to study what happens in terms of college-going or non-college-going in the ablest 10 to 15% of high school graduates in many communities, you would most likely discover that about one-third of this ablest group do not go on to college at all. This happens for any one of a number of reasons which appear to be largely motivational and related to lack of encouragement by parents, teachers, older friends, or friends of their own age.

Some years ago when I was counseling students at Purdue University, I was amazed to find one very able freshman who told me that he had never thought about going to college until he had taken the Navy College Aptitude Test and discovered that he had a very high score and that the Navy, through its NROTC program, would pay his way through college. Three things are significant here: (1)

that he had not realized that he had the ability to do excellent college work; (2) he had not initially been motivated to go to college; and (3) the fact that he was alerted through the NROTC selection program. When he found that he had excellent college potential, and was simultaneously given an opportunity to finance his way to college, these circumstances created enough interest to make him go to college. It is obvious that engineering and science cannot claim all of this ablest one-third of the top ten to 15% who do not go on to college. If we were able to run aggressive campaigns in this country to identify prospective engineering, science, and other college-going talent, engineering would properly have to be satisfied with its own share but yet like the other groups mentioned would benefit by an increased number of able applicants.

To my mind, this problem of the early identification and the adequate utilization both in high school and in college of prospective engineering talent is of major importance to the nation's future. The engineering profession, secondary schools, and industry can, if they work together, discover and utilize far more effectively than we do today increasing numbers of qualified prospective engineering students.

For those of you who would find them of interest, I suggest reading two pamphlets developed from drafts I prepared several years ago which are receiving wide acceptance from secondary schools and engineering colleges. One of these is called "Secondary School Guidance Memorandum—Engineering" and the other "Tests for the Selection of Engineering Students." These are available without charge upon request to Educational Testing Service, Princeton, N. J.

College Notes

To stimulate further development of electronic devices for healing the sick, Hewlett-Packard Company of Palo Alto has established a $2,000 Medical Electronics Fellowship at **Stanford University's** School of Engineering. The Hewlett-Packard fellowship is intended for a graduate student whose major interest is electronics, but who is also interested in medicine and biology. It thus permits him to study for an advanced degree in electronics, with additional subjects in chemistry, biology, and medicine.

Mrs. Lois G. McDowell, assistant professor of mechanical engineering at **Illinois Institute of Technology**, has been elected national president of the Society of Women Engineers for 1955–56. The Society of Women Engineers is the national professional organization of graduate women engineers and women with equivalent engineering experience. Incorporated in 1952, the society has sections in 18 cities and three student chapters.

Professional Engineering Ethics in Practice*

By KENNETH A. MEADE

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Ethics has been described—rather facetiously—as "something that is good for the other fellow." Webster defines it in one way as "the science of moral duty; broadly, the science of ideal human character." As applied to a specific segment of people, or to a professional group, it is often defined as a "system or code of standards."

Physically, man's vision is limited by the function of his two eyes—which permit only a restricted forward view. But if man had a third eye—an inward view, so to speak—that would enable him to see himself as others see him—the task of devising and living by a system or code of standards would be enormously simplified. Such a vision would enable him to penetrate much deeper into his actions and show what is in his mind and heart.

Since ethics implies moral duty and responsibility, its foundation is something which lies much deeper within each of us than merely human eyes can see—although, to be sure, the results of a man's ethics are often painfully visible. The gunman who points a pistol at our hearts and demands our money or our lives cannot and does not want to conceal the terror of his weapon.

By the same token, man's ethical actions can be inspiringly apparent. The policeman who disregards his own safety and welfare while apprehending a gunman—or would-be assassin—is courageously displaying an obedience to moral duty. He is living up to the standards or code of his calling.

Here both the gunman and the police officer are acting according to their own acceptance or rejection of a code of ethical standards. And while their actions are visible—that which *motivated* each to act as he did lies within himself and is not visible. For while man is by nature basically good, he has, nevertheless, the freedom to choose between good and evil. Consequently, his actions are seldom entirely good or entirely bad. One of the functions of any code or standard is to remind him of the good and keep him steadfast in his free election to make his actions conform to the good.

Because of their precise and quantitative habits of thinking, scientists and engineers often find it difficult—when considering ethics—to understand or appreciate the inward patterns that lead men to behave as they do—that lead men to select the lesser good—and in some instances, the evil. We are able to detect the minutest flaw in the metallurgical structure of a huge flywheel by means of modern instrumentation; we are able to detect the slightest impurity in a metal by chemical and spectrographic tests; we are able, by selection, analysis and synthesis, to obtain purity in most material things. Yet, it is impossible to detect, much less predict, the purity of man's inward reasons for acting in an ethical or unethical fashion. We have yet to discover an instrument that will detect those inward motivations and subtle nuances of character that prompt men to deviate from the right and the acceptable.

* Presented at the Annual Meeting of ASEE, ECAC Conference on Professional Development, Penn State University, June 23, 1955.

Because this is true, we then must rely for our judgments of others on the limited basis of outward, visible evidence. We never know with absolute certainty that when our neighbor says "Good Morning" to us that he really means it. Or that the words used in a particularly glowing letter of congratulation necessarily express the writer's sincere feelings. But we can admire each for the gesture.

It is impossible to attach a positive or quantitative value to the ethical actions of people in general—or of engineers in particular. Every person has his or her own personal set of values—and these are largely determined by such factors as the individual's religious and social conscience, experience and environment.

But it is possible to provide both the individual and the group with a code or canon based upon sound moral and ethical principles that can serve to remind them of their responsibility and help them to achieve the highest possible degree of personal and professional integrity.

I have studied the 1953 report of The Committee on the Promotion of Ethical Standards (now the Committee on Ethics) of the American Society for Engineering Education, headed by C. J. Freund, Dean of Engineering at the University of Detroit. It was an excellent study which reached ten conclusions and made four recommendations. I should like to dwell for a moment on conclusions No. 2 and No. 7, which were:

(2) Engineers have an excellent reputation for integrity with the general public.

(7) Criteria exist for both general and professional ethics.

That engineers have an excellent reputation for integrity with the general public is not an accident. It occurs to me that we should with one hand pass a bouquet to the profession at large for establishing and enforcing a self-imposed standard of behavior and to the engineering educators who have been responsible for impressing the importance of these standards on their students. With the other we should present an ethical scale whereby today's engineers may continue to weigh their standards so that the same favorable things can be said of them in the future.

What would be the nature of this scale of ethics which we might hand to today's engineers? Dean Freund's committee considered several approaches for arriving at an evaluation of ethical professional conduct. They considered several criteria—the golden rule, the natural law, tradition, and religious teachings—before concluding that "any general system of ethics must rest upon more than one criterion or authority." Since many of the concepts involved in the criteria mentioned (and in any others which might be considered) are abstract, the contemplation of an ethical scale by the engineer, who is used to thinking in concrete terms, is not an easy task—quantities, mathematical formulae and measurable dimensions are his forte.

However, because engineers do have an excellent reputation for personal and professional integrity in the opinion of the general public, it must follow that whatever system is now being used to maintain these high ethical standards is a worthy one. The standards set down in the "Faith of the Engineer" and the "Canon of Ethics for Engineers," adopted by the Engineers Council for Professional Development, are firmly rooted in the principles of ethical conduct. To quote from the foreword of the latter, "as the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers, and with fairness and impartiality to all." The principles and maxims contained in both these documents have helped to inspire responsible attitudes and foster an environment that has resulted in very high standards of professional integrity.

Environmental Condition

Perhaps it might be well, then, to examine the environmental condition under

which engineers work. Every engineer, of course, contributes to his own environment because he is by profession one who deals with those material and force relationships that surround us. It is needless here to recount his importance to society except to point out that, in number, engineers represent only a fraction of a per cent of our total population of about 165,000,000. This importance is reflected in practically every man-made thing which we own, borrow, or use. Without their contributions, both our national security and our increasing standard of living would be seriously jeopardized. They are by the nature of their profession called on to assume an important role at all levels of our society wherever they may work. Because of this, each engineer contributes largely to the shaping of his environment and of the environment of those around him.

I represent an industrial organization which employs a significant number of engineers. We have some 9000 graduate engineers at work in more than one hundred locations and, because of the diversity of our products and our decentralized operations, the environment of individual engineering groups probably differs in detail—but not in overall perspective.

In our organization, there is no special environment provided for engineers that is different from that for other employes. Rather, there is a common climate for all, regardless of the type of work done or the individuals involved. This working climate, or environment, is outlined in six basic principles that serve as a guide to all those responsible for the management of the business. They are also brought to the attention of every employee in the company as a guide in discharging individual and collective responsibilities.

These principles are:

(1) *Put the right people in the right places.*

In the case of the engineering graduate, this implies that he will be given a working assignment which will enable him to develop himself vocationally along the path which he selected when he decided to study engineering, and eventually to make the maximum contribution of which he is capable to the business, to the profession and to himself.

(2) *Train everyone for the job to be done.*

On-the-job training and orientation programs are set up to assist him in developing his talents and skills to their utmost.

(3) *Make the organization a coordinated team.*

In none of these more than one hundred locations do engineers work as "ivory tower" specialists in splendid isolation. Each has a place to fill in an organization which is welded together by common goals and the individual engineer contributes but a part to the overall achievement. His work is communicated to others and becomes valuable only as others on the team take advantage of what the engineer is able to contribute—whether his work be on the drafting board, in a dynamometer room, in manufacturing process development, as a production supervisor, or whatever his assignment. However, the organization of the team and the evaluation of its work by management are such that individual initiative and individual recognition are encouraged.

(4) *Supply the right tools and the right conditions.*

Few engineers can be productive without the proper facilities with which to work. A few might make their maximum contribution with the aid of nothing more than their intellects—and perhaps a little paper and a few pencils; but, for the most part, today's industrial needs are so complex that a very large investment is needed per engineer to provide the necessary laboratory and other facilities required to do the job which will keep the customers satisfied. Most of our engineers are engaged in a simplifying busi-

ness—making the complex simple so that it can be useful. The facilities required to make a simple device for dimming headlamps, for example, are quite considerable.

(5) *Give security with opportunity, incentive, recognition.*

While each engineer must capitalize upon his own opportunities to progress, incentives are provided to stimulate him to develop the best that is in him. These incentives are in the form of recognition within his own group; recognition by those above him in the line of management within the organization; and recognition in the outside world through technical society and community work. There are also financial rewards in the form of merit increases in salary commensurate with his individual contribution and responsibility. This is an important incentive always.

(6) *Look ahead, plan ahead . . . for more and better things.*

Much of this function is the responsibility of the company's team of engineers and scientists engaged in research, styling, product development and production guided by top management.

There you have the six basic principles which create the climate for the individual engineer's conduct in one typical industrial organization. These principles are founded on the concept involved in establishing the decentralized plan of operation for the organization developed during the 1920's. Mr. Sloan in his book "The Adventures of a White Collar Worker" in explaining his concept of how such an organization should be established said, "Divide the organization into as many parts as consistently can be done; place in charge of each part the most capable executive that can be found; develop a system of coordination so that each part may strengthen each other part, thus not only welding all parts together in the common interests of a joint enterprise, but importantly, developing ability and initiative through the instrumentalities of responsibility and ambition; and developing men—giving them opportunity to exercise their talents both in their own interest as well as that of the business."

In the 1940's a statement of these basic principles that I have just outlined was adopted as a guide to be followed in the operation of the business. When Mr. Harlow H. Curtice became President of General Motors in 1953 he again emphasized the importance of these principles to the continuing success of the organization in establishing, developing, and maintaining the right working environment.

You have probably noted that all of these principles deal with people. You will further note that each one of these principles implies a two-way responsibility. The responsibility of the organization to provide the opportunity and incentive—and the responsibility of each employe to make use of these tools in his own development.

Most folks would agree that these principles, if all were applied at all times as intended, would provide an ideal climate for proper individual ethics. It would be an exaggeration to claim that in application all of these principles are perfectly applied or maintained in perfect balance at all times, but each is a goal which our people try to achieve. Since all people have human frailties which evidence themselves even above the most sincere efforts to avoid them, here and there a small storm cloud does sometimes develop which darkens this apparently utopian sky.

Now what can be done when something happens to becloud this utopian climate? What is management's responsibility in the development of an environment that will promote the maintenance of high professional and ethical standards? What is the employe's responsibility?

All sound business principles or policies take into account the equities of every person and part of the total operation.

When policies are sound, the equities of all are in proper balance. The returns for shareholders are equitable and the rewards to each member of the working organization, from the top manager to the newest employee, are in balance—according to each individual's contribution to the success of the business; the quality of the product and its price are balanced so that the customer's best interests are served; and in every other aspect the equities—as opposed to the wants and the desires—of every individual concerned are taken into account and satisfied.

Let us consider for a moment the problem of placing the young engineer on the job. Once he has obtained his basic education as an engineer, it is up to his employer to place him in a starting job which will afford him an opportunity to make use of his training and at the same time provide for his own self-development. Later in his own self-development, he may be led into fields of activity other than engineering in which his contributions are more beneficial to himself, to his company, and to society at large. In any case, the decision as to which is the best place for the man in the organization must be arrived at through mutual understanding. Proper placement remains a mutual concern throughout his years of employment.

Training is a dual responsibility. The company places the training opportunities before the employe, but the employe must use these to improve his "know how" and develop himself according to the opportunities which are provided by management and which he makes for himself as he progresses.

Personal Code of Ethics

The contribution of the individual engineer to the overall group objective depends to a large extent on his personal code of ethics. The Canon of Ethics and the Faith of the Engineer both emphasize the necessity of a favorable attitude on the part of the engineer toward his work and his responsibilities. They also stress his favorable attitudes toward people. In the final sense, if followed, the ethical code of the engineer will lead him to a more wholesome attitude toward life in general. If he looks upon work not as drudgery to be endured but as a means of bringing out his innermost values for his own benefit and, as importantly, for that of the people around him, he assures himself success which cannot be measured by any standards created by man. If he recognizes the equities of all his associates and looks upon those around him as both a responsibility and as sources from which he may draw help in his own work, he ennobles his stature as a man, the only creature on earth who can be creative for the good of his comrades. A primary responsibility of management in this team-forming and team-working process is to recognize and reward those who by their own self-development and initiative figuratively raise their heads above the crowd.

This point, recognizing the individual, is much broader than evaluating his potential or promotability. In the case of the engineer, it includes providing an outlet for him to communicate the non-confidential results of his work to other engineers and to those not directly concerned with his work. Here, we mean appropriate encouragement in the development of technical society presentations and papers for publication and in committee and community work. Recognition within the organization is important, but that from outside the organization also contributes to the engineer's sense of well-being and personal value.

The matter of providing tools is almost wholly an employer responsibility, but here the employe may be responsible in some measure for making the recommendations which will lead to the selection of the best facilities to help the team do its job better. At the same time he is importantly responsible for the continued maintenance of the effectiveness of these facilities and putting them to their best

use in his part of the engineering program of the organization.

Planning and doing the job which needs to be done—embraced in the sixth point—is one of the major responsibilities of the engineering organization and here ethical standards as applied to the equities of all concerned are of extreme importance.

Engineers have set a high standard of professional ethics. The integrity of their professional opinions and decisions has been outstanding. The results of these standards are evident in the magnificent sturdiness of a dam which holds back with certainty the pressure of a river. They are evident in the school bus loaded with gay and carefree children crossing a suspension bridge in absolute safety. They are evident in the sure ease with which a crane picks up its load of steel and moves it to another part of a manufacturing plant. They are evident in the mechanism which responds to the touch of the brake pedal in a speeding automobile. They are evident in the security of the pilot as he pulls his aircraft level after a power dive. In these and countless other examples, the engineer's professional knowledge applied with integrity adds to the benefit and security of us all.

In the conduct which men expect of each other for the betterment of the world, the engineer is measured in the same abstract units which are applied to men of all professions and callings. I am firmly convinced that no person—engineer or whatever his calling—can take the whole credit for his achievements or his contributions. His abilities were provided by his Creator and without some measure of Divine guidance his efforts would not reach their greatest possibilities. By the same token, man cannot devise or apply any code of ethics worthy of the name without the aid of some Power greater than himself. Whatever may be his inner character—*ethikos,* from the Greek—his actions and attitudes will record it to the pleasure or displeasure of his comrades and his God.

Summary

In summary, maintenance of a high level of ethics by and for the engineer is a matter of grave national concern. As valuable and sparkling as the engineer's contribution may be, it could tarnish and deteriorate unless given under a code of high ethical standards. Engineers by the very nature of their work affect the mode of living of all of us in more ways than almost any other group in our economy. Thus the engineer is a servant of all men. May this service always be given in the light of equity and justice. This places on every engineer the serious responsibility of doing his work and directing his life according to the highest professional and moral standards that men of the profession can establish and achieve. Thus the engineer can enjoy the ultimate in personal satisfaction from his job and the contribution he makes to the betterment of the world in which he lives.

In the words of a proverb: "Help thy brother's boat across, and lo! thine own has reached the shore."

Eastern Joint Computer Conference

The Eastern Joint Computer Conference will be held November 7 through 9 at the Hotel Statler, Boston, Mass. J. G. Brainerd, Director of the Moore School of Electrical Engineering of the University of Pennsylvania, will be the keynote speaker.

University Technical Writers and Editors*

By LISLE ROSE
University of Illinois

We technical writers and editors are concerned with our skills and our status. We have grown so fast in numbers and responsibility that what we thought we knew about ourselves needs reviewing. We have to take stock of our collective skills and look at our position. We also want to look ahead, decide what we wish our skills and status to be, and plan how to bring them to that point. We want to know where we are, to set goals, and to figure out routes.

People whom universities and colleges call editors are all over the lot. Their range of duties is about as great as you can get from differing local needs and traditions and from a wide though tight supply-market. Their origins too are varied. College technical editors have come from engineering, sales, advertising, public relations, the city desk, scholarly journals, English and other academic fields. Their present jobs may bear small relation to their past ones.

Now, as TWE members we do not care about the peculiarities of college setups and college folk. But from the great variety within the field of college editing and from the causes and effects of that variety we may learn some lessons of general import.

Perhaps I should have used charts and/or statistics to show the variety. I did begin a chart. It was to symbolize how the schools assign editorial (and related) duties and how widely the official and the real jobs often differ. The chart got Dali-esque. I also played with the notion of a frequency diagram. But such a diagram may go out of date fast. The basis of many current practices may well change soon. Partly because of TWE studies academic people will learn that, if Topsy cannot be born again, at least her growth can be directed by principles. As a group we school men are beginning to feel sharply the lack of such principles —first step toward developing them. And as we develop them, today's welter of practices should give way, not to sameness, but to a much-needed order.

First let's see what the welter is. For information on this—on current situations and practices—I'm in debt to fourteen university and college technical editors and ex-editors who gave details on eighteen schools differing in size, location, purposes and structure. I hope they are representative samples. Help has also come from deans, directors, teachers, research men, and a few technical-press editors.

Papers at previous TWE meetings have shown how great is the number of tasks performed by technical editors in government and industry. When it comes to the schools we have to say, "Raise you two." One reason is that editing done in technical colleges is not identical with technical editing. It includes more, because much of the administrative work in such schools, plus many of their external contacts, and even some of their research, are not technological yet yield editing jobs.

In one or another engineering college, editors do all the kinds of chores performed over a period of some centuries by both newspaper editors and scholarly

* Prepared for Spring Meeting of Technical Writers and Editors Association, May 12, 1955. Shortly afterwards, members were saddened to learn of the untimely death of Lisle Rose.

editors. Their work extends from discerning, or even implanting, a gleam in the author's eye, to and beyond seeing publications through the press.

This is to be expected. Likewise to be expected is the host of non-editorial jobs done by people who are labeled editors. Some of these jobs can be called editorial —preparing scripts for radio, TV, and movies and for demonstration-displays, advising the staff of a student magazine. But other jobs done by editors are not editorial at all, unless we follow Alice's motto. Another way to put it is this: when we talk about technical editing in our colleges and universities we have to talk also about publicity work and about two of its forks—advertising and public relations. Nor can we talk only about the personal performance of these functions. We must regard their supervision and administration as well. We have to talk about teaching; and this teaching ranges from individual "tutoring"—Markup Hopkins on one end of a blue pencil and a faculty or student writer on the other —to formal class instruction for professors, for novice researchers, for undergraduates.

We even have to talk about overall management, for in some schools the editor has ended up as a part of the college's management team. He is usually the communication specialist on the team, but he is not that only. He helps to plan and carry out policy concerning the curriculum, faculty promotions, the budget, etc., etc.

A related fact is that several academic people who are called editors bear other titles in addition.

Finally, in many schools we find certain editorial tasks assigned to people who are not technical editors by profession or name.

All this diversity cries for analysis. We have to start our analysis by sketching the factors that have influenced the schools in their hiring and use of communication specialists. These factors are essentially the same as in government and industry, but within the schools they take some special forms. And, of course, their weight varies from institution to institution.

One obvious factor has been the supply of money. In many schools this supply has been so small that editors have to double or quadruple in brass. Another obvious factor has been the supply of persons. Qualified editors, photographers, illustrators, and other needed personnel are hard to find even today; they were still harder to find twenty years ago, when many of today's setups were installed. Hence a number of square pegs in round holes. Hence, too, the rounding out of some square pegs and the squaring off of some round holes.

Differences in Institutional Structure

Nationwide, just as big a factor has been the nature of differences in institutional structure. Of course, structure changes somewhat with time—and not always rationally. Most engineering colleges once operated on a pretty rigid line-basis; the shift to line-and-staff (a shift which in some schools has partly been caused by the demand for and the supply of communication specialists) has been general but not, on the whole, very carefully planned.

By and large, independent engineering colleges have been slower than their "bound" counterparts to see the need for an editor or similar specialist. This has been so in both line and line-and-staff setups. On the other hand, many independents have been freer to hire and use communication specialists as they think best.

Regardless of whether an engineering college is a whole or a part, we have to consider its internal structure. In many schools there is a tug between specialization, above all between specialization in research, and stress on that kind of communication that is called teaching. To simplify (unduly) let's say that research specialization has tended, markedly in this era of research teams, to produce a de-

mand for technical editing and then a demand for enlarging the volume of editing but not the scope. Research specialization has also led to much routinizing of editorial procedures, a trend reinforced by federal contract work. Teaching-oriented schools, I think, tend to give editors more kinds of jobs and to play down routinization.

So far I have been talking about the official structure of schools. The real structure may of course be something quite different, for attitudes—which I believe have played an even larger part in the operation of schools than of industry or government—attitudes sometimes bulwark the official structure, sometimes crack it, and once in a while dynamite it. So the question whether a communication specialist shall be hired, and then the question what duties and powers he shall be allowed, may be decided less in terms of the organization chart than by the emotions of research specialists.

The attitudes of administrators are important also. A number of old-line engineering deans looked at communication as opposite and inferior to action. Slowly, they or their successors have come to realize that communication is an integral part of action—a gain for the editor.

Teachers' attitudes have had a more scattered effect. Many teachers are pretty individualistic and dislike any additions to the administrative scaffolding. In a school where there are a lot of men like this, an editor may have had to be smuggled into the organization and may never gain status that his work and powers deserve. Other teachers regard themselves as communication specialists and resent being guided in any talks or writeups, however strongly institutional, that they prepare—though they may not object to an editor's doing promotional material. In counterbalance, many faculties contain influential teachers who have analyzed communication thoroughly enough to realize that teaching is only one mode of communication and that technical editors have a place to fill.

Another internal factor has been the committee system. That system gets deans and teachers used to seeing quasi-administrative jobs done through part-time channels. As a result, in some schools an English Department member has moved from the chairmanship of the college's publication committee to a permanent publications post.

So far, I haven't used the word "concept." But it is clear that the official structure of an organization, and the attitudes related in diverse ways to the structure, theoretically and often practically rest upon concepts. Some of these concepts are ex post facto, devised to explain and perhaps to justify what has already been done.

Let's look at the divergent concepts of an editor's function that the technical schools consciously hold and then at some that we can find with the x-ray.

In several schools the functions are conceived on the basis of a descending series of dichotomies. To use plain English, we halve the apple, halve it again, and keep on slicing. The editor then is considered as dealing not with action but with communication; with verbal communication only, not with graphical or mixed; not with oral communication but with written; with institutional documents, not with an author's "personal" output (whenever the line may be drawn); with the "form" and not the "content" of documents (in whatever way form and content may be defined). An editor so circumstanced will perform one of the four jobs which Irving Rosenbarker has said all technical editors should perform; that is, he will help authors to communicate ideas. Even this task he may do poorly. And he will probably not do at all the other three jobs that Mr. Rosenbarker named: He will not improve publication scheduling; he will not broadly or permanently improve an author's abilities; he will not improve—he will probably impair—the relationship that we like to see between editors and authors.

Via Mr. Rosenbarker, we have just

moved over to another set of concepts that affect the technical editor's work and status. These concepts relate to a college's personal-contact philosophy. In most small schools, close touch between faculty and students is common and it tends to be carried over to intra-faculty behavior. Large institutions generally try for these goals, but don't always reach them. So the size of the school may influence the relationship between editor and writer. Of course, a college does not necessarily share the traits of its university. A small engineering school in a large university may have a friendly and intimate faculty. Even large engineering schools within large universities may seek and get a lot of genial face-to-face contact.

The concepts I have just been talking about, though pretty superficial, are as far as many colleges have gone in their thinking. But *we* can go further. We might do so through an approach that Drucker takes in his recent "The Practice of Management."

Basic Operations

Drucker finds five basic operations in the manager's job: Setting objectives, organizing, motivating and communicating, measuring, and developing people. These add up to managing the business, managing managers, and managing work and workers. We might note that Bob Hamett's chart (Fig. 4) in his "Technical Writing Grows into New Profession" covers these three functions though not by name.

As to the first, colleges differ widely in their answer to the question, "What is the business, if any, that an editor should manage?" I've said that a few schools believe he should help manage the college's whole business. Others leave him virtually no business to manage at all—even the format of his publications and indeed the style book that is to be his bible are imposed on him by a dean, a director, project supervisors, or sponsoring agencies. In such a situation, the college has not yet realized that there is a difference between the *business* of editing and the *work* of editing. If an open or tacit distinction *is* drawn, the concept of the editor's business may not include calling on him for innovations; he may be expected only to do better what his predecessors have done well. In other words, he doesn't set objectives, he merely accepts them—with all that this implies about motivating other persons, developing them, and measuring them and their output.

When we consider Drucker's second function—managing managers—we again find much diversity. Assistant editors and/or editorial assistants may be treated as workers, or they may be given managerial authority. Technical illustrators and photographers are, I believe, more likely to be at least submanagers. Design specialists within an editorial organization are very likely to have managerial status.

Where to place authors within Drucker's scheme is a problem. Some authors, to repeat what I said in other words, want to consider themselves as the managers and the editorial staff as workers or even as flunkies. An equally grave mistake is made when the pendulum swings to the other end of the arc. In good organizations there is actually a constant shift of status—at least during face-to-face contacts—on the part of an editorial man and his author. Now one, now the other is teacher; now one, now the other is decision-maker. I don't need to labor the point, except to say that in the technical colleges the trickest situation usually arises when an editor feels that a manuscript or talk should have substantive changes. Many an author then feels that his professional competence is being questioned.

Another group that is hard to classify and deal with consists of reviewers of manuscripts submitted for publication. Paid reviewers cause little trouble. Unpaid colleagues of the author had best be treated as I have implied that authors themselves should be treated—essentially like co-managers pro tem.

When we discuss either the business or the work of editorship, we can't avoid talking of remedial, preventive, and constructive operations. Some schools, even today, think of editorial service as mainly remedial—the correction of authors' rhetorical errors. And these errors may be defined just as the most hidebound of 18th Century precisians would have defined them. There are other schools which, in order to replace dosing by prevention, set up conferences or classes for authors. There are still others whose formal teaching or whose use of "tutorship" is inspired by more positive considerations:

1. Instructing authors in documentation.
2. Instructing them in scientific logic and methodology.
3. Trying to make them collaborate more effectively with fellow faculty members.
4. Giving them a feeling for the institutional approach in their research and writing.
5. Trying to make them better practical psychologists—not only in their writing but in face-to-face contacts.
6. Trying to make them more well rounded social beings.
7. Trying to inculcate in them a humanistic attitude.

Let me move our telescope. While doing so, I shall borrow a lens from School of Education people. They talk of the child-centered school, the teacher-centered school, the subject-centered school. Let's think briefly of editing as person-centered, product-centered or process-centered.

Then let's divide persons into natural and artificial. First for natural persons.

Some college editing is done to suit authors. Their reaction is the basic yardstick. Plainly, the results can be good or bad; they generally are bad. But when "author-centered" means that the editor tactfully teaches his authors, then the results can be good.

Second, some editors try only to suit individual bosses; if Dean Jones or Project Director Smith likes a report, a manual, a bulletin, that is enough.

Third, a few editors try to suit mainly themselves. No comment.

Presumptive Readers

Of the natural persons on whom editing may be focused the most important are actual or presumptive readers. Most of us college editors know too little about these readers. We need to become more familiar with our customers, particularly when they are many and various. We need to make more market surveys than we do, and better ones.

To move from natural to artificial persons, let's note that some college editors are promoted or fired on the basis of institutional approval. An institution may or may not be personified in one man or a small group. Of course a number of institutions may be concerned with the editor's product—as an assembling agency, as an authorizing agency, a reviewing agency, an issuing agency, a using agency. In a few schools I know of, these institutions are one. An engineering department, for instance, may prepare a bulletin, review it, authorize it, determine at least the basic content and structure (even over the editor's objections), and measure the worth of the bulletin by the judgments of its own members.

What I mean by "product-centered" is a little vague, even to me. I'll use the term to denote operations that are governed mainly by mere bigness. "The more pages we put out the better we are." Each document or other end-product is treated as an isolated unit except in so far as it pads the statistics.

Sometimes this criterion is hard to distinguish from that used by the process-centered office. In such an office the god may be system or the god may be speed. Most commonly he is efficiency, defined in terms that would have suited Taylor. That is, the stress is on certain kinds of systematization, not for its own sake but as a means to saving time and money. Let me say that many college editorial staffs

might respect this god more than they do. It is only when he becomes an idol that he is dangerous.

Perhaps we should add a further category—craft-centered editing. When the craft is the focus of attention, editing may be done for a fairly few experts whom the editor regards as his peers and judges—and some of these experts are dead. The experts, living and dead, are conceived of as possessing a taste which is lacking in the other persons with whom the editor deals—authors, his bosses, the bulk of his readers. Just which craft is focused on will vary from editor to editor. It may be the craft of journalism, it may be rhetoric, it may be typographical design.

I think it is clear that not all the schools are sure whether editing is a set of techniques, a craft, an art, a science, a business, or that combination of the five which is a profession. Nor are they all sure whether it is desirable to leave paths open by which editors may move out into non-editorial fields. They are not clear either on some logically smaller but practically very important matters; for example, the relative stress they should place on economy of time as against a set of functions that many colleges emphasize—the editor's tutorial and teaching functions. Assuredly they are not in agreement as to the kind of training an editor should have before appointment and on the job. The big fight of course is over engineering as against "verbal" backgrounds. My graying verbalistic self and my graying compeers are probably a passing evolutionary phase. Perhaps we are the dinosaur. Perhaps we are the kangaroo, a holdover adapted to a special habitat. Perhaps we are the eohippus, whose descendants include the zebra, the Shetland pony, the Arabian, the Percheron.

That most technical editors in the colleges and universities are doing a fine job is a tribute to their innate abilities and conscientiousness, and a further proof of the fact that people with those traits serving under or with supervisors of good will and high intelligence will usually "get out the work."

All the same, collectively we need a firmer base for our operations. We in the colleges might well study with care the functions of the publications engineer as Hamlett has worked them out and charted them. We ought to see how adaptable his and other systems are to our needs, philosophies, and ground rules. A study of Hamlett's and similar charts might lead some schools to change their concepts of their needs, to clarify their philosophies, and to rebuild the pitcher's mound and move the outfield fences. I know that I myself need to do these three things.

Management Audit Desirable

I think, too, that many of us college editors could profit from a management audit like that which the American Institute of Management makes for its members—an audit in terms of the subject-organization's

economic function
internal structure
health of growth
service to sponsors
development policies and their results
fiscal policies
operating efficiency
public service, and
executive (or personnel) evaluation.

I shudder to think what such an audit of my own office might reveal; and I ought to shudder.

Finally, all of us in technical writing and editing need more data—not only data about current practice but also attitude and opinion surveys. What do we think we ought to be doing, how, and with whom? What do other persons think? Which of these other persons matter to us? Many of us would be happy to see TWEA, as a national organization with an important social function, take steps toward planning for such surveys, analyzing and disseminating results, and thus contributing still further to our professional development.

Needs of Electric Power Industry for Nuclear Engineers*

By R. W. HARTWELL

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and

H. A. WAGNER

Assistant Manager of Engineering, The Detroit Edison Company

Introduction

To use nuclear energy for peaceful purposes is an expressed aim of not only this country, but of many of the European countries as well. One of the more important fields in which the peaceful use of nuclear energy appears feasible in the relatively near future is electrical power generation.

In discussing the need for nuclear engineers in the electric power industry, it may be pertinent to consider: (1) why the demand has suddenly become so great; (2) how many nuclear engineers will be needed and how soon; (3) how nuclear engineers will be utilized; (4) what capabilities these men should possess; and (5) what can be done to assist in fulfilling the need for engineers.

Increased Activity

The determination on the part of industry to carry forward the development of nuclear power plants was greatly reinforced by the passage of the Atomic Energy Act of 1954. Prior to that time, the inability to own reactor facilities as well as fissionable material limited the interest of private enterprise. Further, the policy of the U. S. Atomic Energy Commission to declassify more and more information, and to make it easier through "access agreements" for private enterprise to investigate and study the potential application of nuclear energy to their own business, has added greatly to the interest in atomic energy.

As an indication of the increased industrial interest in nuclear energy applications, it is observed that as of April 1954 there were eight study teams with Atomic Energy Commission agreements. These eight teams were investigating at their own expense the feasibility of producing economical electrical power with nuclear reactors. Some forty industrial and utility concerns were involved in this program. Today, one year later, twenty study teams consisting of more than 75 different industrial and utility concerns are actively involved in this AEC industrial participation program. Over fifty electric power systems are engaged in studying the feasibility of generating power by means of atomic energy.

It is significant to note that within the last three months, five independent groups have indicated a desire to build and operate nuclear power plants, four of which are in connection with the AEC Power Reactor Demonstration Program. The construction of these plants would be financed essentially with private capital. There are 25 electric power systems represented in the four proposals for construction of atomic power plants now

* Presented at the 63rd Annual Meeting of ASEE, Atomic Energy Education Division, Penn State University, June 22, 1955.

awaiting action by the Atomic Energy Commission.

As an example of the very rapid growth of interest, one prominent manufacturer of coal and oil burning steam generating equipment used in the power industry formed an atomic energy division in 1953 and assigned four men to work in this new group. In 1954 there were about one hundred engineers and scientists in the division, and by the end of 1955 it seems likely that the division will require the services of more than two hundred nuclear engineers. In most cases, these engineers are specialists in their fields and have been brought into the division from the outside. This growth is taking place in many companies in the electrical industry each month. The pattern seems to be to assign a capable engineering executive the responsibility of reviewing the general field of nuclear engineering to determine what attitude the particular company should take. Usually, this survey results in more extensive application studies and finally actual production in the new field. As each step in this progression is taken, additional specially trained engineering personnel are required.

Estimated Requirements

The need for nuclear engineers in the electric power industry will exceed the supply for the next ten years and possibly for an even longer period of time. This shortage of specially trained engineering personnel will be felt by the manufacturers of electrical power equipment and suppliers, the constructors and erectors of nuclear power plants, and the owners and operators of these new facilities.

The Detroit Edison Company has about 11,000 employes, of whom approximately 750 are graduate engineers. To provide for retirements, for replacements, and for growth, it is our practice to employ 30 to 35 engineering graduates each year. As atomic power plants take a more important part in the new capacity which will be installed, a portion of these graduates should have a nuclear background to enable us to design and operate nuclear plants.

In a recent survey of the atomic industry,† it is estimated that private industry engaged in atomic business will require approximately 3800 scientific and engineering personnel by 1958. The 20,000 engineering graduates available this June will not satisfy the needs of present industry, to say nothing of the expanding requirements of a rapidly growing new enterprise. If the atomic energy program in this country does not move forward as rapidly as now seems possible, one of the primary factors acting to retard progress will be the shortage of trained personnel.

Utilization of Nuclear Engineers

To avoid misunderstanding, it is important that we define what is meant by the term "nuclear engineering." In the broad sense, nuclear engineering is involved in the design, construction, testing, and operation of components and equipment that make use of nuclear processes and materials, as well as in the research and development pertaining to such use. For the electrical power industry, the nuclear engineer is primarily involved with the nuclear reactor and the handling of fissionable materials. A nuclear engineer should have a good background in the fundamentals of engineering, plus a working understanding of nuclear physics and chemistry, and their relation to practical problems.

Since the procurement of full-fledged nuclear engineers appears to pose a considerable problem in the near future, let us consider how the nuclear engineer will be used and what some of his qualifications should be, since this may enable use of engineers now on hand.

After management of an electric power system determines the need for a new conventional power plant and before this plant goes into service, some two to three years later, certain definite engineering

† Growth Survey of the Atomic Industry, 1955–65, Atomic Industrial Forum, Inc., April 1955.

steps must be taken. These steps include conceptual design, final design, specification preparation, equipment procurement, construction and erection, and finally personnel training and operation. While there are some systems which perform all of these functions, many electric power systems engage the services of engineering and construction firms to do various parts of the over-all job. It is for this reason that the size and function of the engineering departments in various power systems are so different today. There is every reason to believe that, as nuclear power plants are designed and built, some operating systems will do more of the over-all job than will others. From an over-all industry standpoint, however, all of the foregoing functions must be performed in building nuclear plants, and the man power must be made available either within the design group of the power system, or in the engineering organization servicing the power system.

In this review, it may be helpful to study the background of the men in the engineering group which has been assembled to carry out the conceptual design and specification preparation for a fast breeder reactor plant. These men are in the working group of the Atomic Power Development Associates, Inc., located in the General Offices of The Detroit Edison Company. This rather unique corporation, which includes thirty-three member companies, is the outgrowth of the Dow Chemical-Detroit Edison industrial study team. Preliminary work was started by this team late in 1950 and continued under an AEC contract in 1951. Since that time the group has grown until now there are twenty-five electric power systems represented in APDA, as well as four manufacturing enterprises, and four engineering organizations.

This project is engaged in the design of a liquid-metal-cooled fast breeder reactor which appears to have real promise for commercial success. Thus far, approximately $4 million, provided by the participating companies, has been spent for the effort, and a work program estimated to cost $3.8 million is planned for this year. The project has not set up a large laboratory, but rather has carried on research and development projects through the efforts of more than fifteen contractors. The corollary effect of engaging in the atomic power business is illustrated by this case. Not only is assistance needed in the direct plant design, but the research and development effort needed to make atomic power truly competitive will require the assistance of many engineers and scientists working in laboratories and elsewhere having no direct contact with power generation per se.

Qualifications

Each of the fifty-one engineers and scientists in the APDA working group has either been made available to the project by one of the member companies or has been hired from the outside on the APDA payroll. Figure 1 shows the organization chart for the APDA working group. Each section has been set up to perform a specific function. The following brief descriptions of some of the section responsibilities will also serve to indicate the type of engineers and scientists needed:

a. *Physics Section*

Reactor physics calculations concerning reactivity changes, material activation, nuclear performance, critical mass, and others are made by this section. Included in the work is the design of a reactor shield to protect personnel and equipment from nuclear radiation. A strong nuclear physics training is indicated, but an appreciation of engineering principles and economics is desirable, even though rarely found.

b. *Fuel Element Section*

The removable portions of the reactor, wherein most of the total reactor heat output is generated, are called fuel elements. The complete design of these

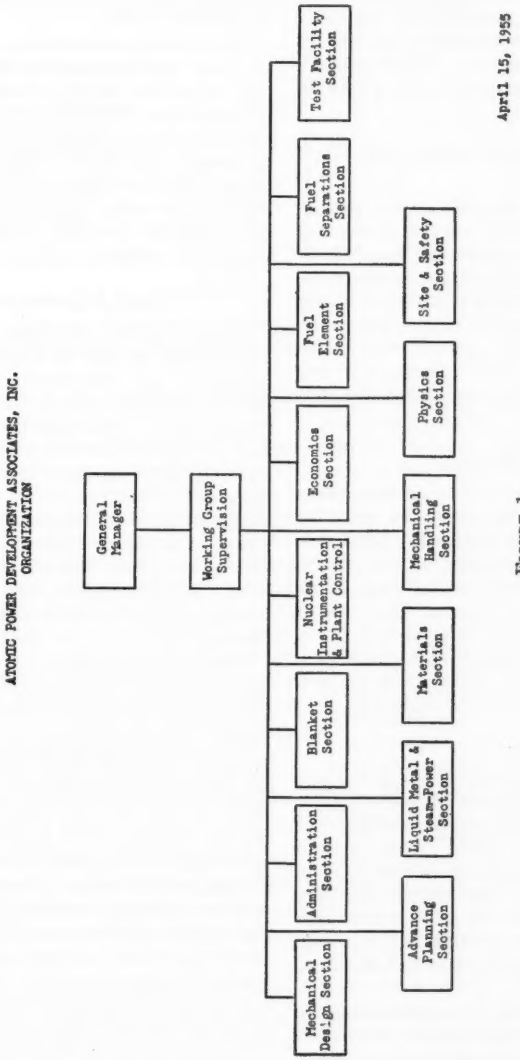
ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.
ORGANIZATION
General Manager
Working Group Supervision
Mechanical Design Section
Advance Planning Section
Administration Section
Liquid Metal & Steam-Power Section
Blanket Section
Materials Section
Nuclear Instrumentation & Plant Control
Mechanical Handling Section
Economics Section
Physics Section
Fuel Element Section
Site & Safety Section
Fuel Separations Section
Test Facility Section
April 15, 1955

FIGURE 1.

fuel elements is the responsibility of this section. In evaluating design possibilities, these engineers must consider heat transfer characteristics, metallurgical and stress problems, and the economics of various manufacturing processes. Mechanical engineers and metallurgists are primarily required.

c. *Nuclear Instrumentation and Plant Control*

This section is responsible for providing a safe and stable control system for the entire nuclear plant and has full responsibility for all controls, instrumentation and devices which affect plant operation. This includes the design and operation of the reactor control rods which regulate power level. Mechanical and electrical engineers are needed for this work.

d. *Test Facility Section*

The test facility section is responsible for the design, construction and operation of a nonradioactive test facility which will be a full-scale prototype of the reactor with one liquid metal coolant loop. This facility will be used to test final reactor components and assemblies as well as for the training of reactor plant personnel. Engineers familiar with research and operating procedures are required.

e. *Fuel Processing*

The primary responsibility of this section is the development of processes for chemical and metallurgical treatment of irradiated reactor fuels. This involves the separation of uranium, plutonium, and fission products so that the uranium may be recycled in the reactor as new fuel. The plutonium is suitable for sale, and the fission products may be stored or possibly sold.

In addition to the process determination and separations plant design, this section has responsibility for fissionable materials transfer, storage and shipping facilities, the radio-chemical laboratories, and radioactive waste treatment and disposal. This work requires the efforts of chemical and metallurgical engineers.

f. *Administration*

The over-all successful accomplishment of these projects requires the leadership and organizing ability of engineering administrators. This is a highly technical field in a state of great change. The need is nowhere greater for able engineers to secure the cooperation and guide the efforts of the many types of engineers and the scientists required to bring such a project to fruition.

Basic Requirements

There may be some misconceptions concerning the number of highly theoretical physicists and mathematicians that are needed to design, test and build a power reactor plant. Basic reactor design work and performance calculations must be accurately done by such specially trained personnel. For this work, the physicist, mathematician or engineer draws on many years of academic training and possibly five to ten years of work in the nuclear field. It appears that only a relatively few on a project such as ours require this background.

Most of the engineers engaged in reactor and reactor component design require only a limited knowledge of nuclear concepts. Familiarity with the terminology must be obtained by an engineer before he can really contribute in the nuclear field. It has been our experience that engineers having a good background of engineering training and a sincere interest in the nuclear business can and will obtain an adequate working knowledge of the nuclear physics needed in a comparatively short time. A summary of the educational background of the APDA working group is shown in Figure 2. The large number of mechanical engineers involved in fitting the fast breeder reactor and its various systems together is always surprising. Many of these engineers concentrate on "hardware" type problems

FIGURE 2

EDUCATIONAL BACKGROUND OF APDA WORKING GROUP PERSONNEL

	B.S.	M.S.	Ph.D.	ORSORT*	Total
Chemical Engineers	3	1	–	–	4
Civil Engineers	1	–	–	–	1
Mechanical Engineers	20	3	1	(1)	24
Electrical Engineers	4	2	–	(2)	6
Metallurgical Engineers	2	1	–	–	3
Physicists	2	4	1	(1)	7
Physical Chemists	–	1	1	–	2
Mathematicians	–	1	–	–	1
Lawyers—LLB					1
Administrative Personnel					2
					51

* Oak Ridge School of Reactor Technology.

which are absolutely vital to the operation of the reactor plant.

Special requirements of a reactor system may have a pronounced effect on the design of pumps, valves, fittings, insulation, piping and heat exchangers. This is surely the case in a liquid-metal-cooled reactor system where very large quantities of molten sodium and sodium-potassium alloy must be circulated. Likewise, it is the case where reactors are cooled with very high pressure water which must be maintained in a completely clean, virtually leak-tight stainless steel system. These special design problems are solved by capable mechanical and metallurgical engineers who at the same time understand the general requirements of nuclear processes.

Satisfying the Needs

In attempting to meet the demand for engineers in the nuclear field, it would appear that three principal courses should be helpful.

1. Every possible assistance and encouragement should be given to our engineering colleges and universities to enable them to provide the training needed. In our opinion, this can best be accomplished by adding to the established engineering curriculum, possibly in the form of graduate work. The basic engineering training should not be sacrificed in favor of nuclear subjects, since by far the larger part of the design is concerned with basic engineering.

The training provided by the AEC through the schools at Oak Ridge and Argonne National Laboratory has been of tremendous value to those engaging in the study of nuclear power. Also, the Atomic Energy Commission's willingness to permit engineers from industry to work in AEC contractors' facilities has been most helpful.

2. Research and engineering projects may be placed in universities to enable them to provide training to personnel already on hand. Direct contact with the practical problems which arise in utilizing atomic energy will serve to supplement the principles which have been learned in the classroom. As an illustration, APDA, Inc. has a contract with the University of Michigan to study and evaluate certain phases of chemical and metallurgical reprocessing; with Rensselaer Polytechnic Institute to develop a scrap recovery system; with the Battelle Memorial Institute to study improved methods of making fuel elements; and others. APDA has also made arrangements with the Institute for

FIGURE 3

CASE HISTORIES—ACADEMIC AND TRAINING BACKGROUND

Engineer	Section	Age	Formal Academic Training	Additional Training	Employed by	Period of Employment Prior to Reporting to APDA, Inc.	Duties Prior to Reporting to APDA, Inc.	Years with APDA
A	Fuel Element	29	BS-ME 1948 MS-ME 1949	Instructor during last 2 years in school; also work on research project	Electric Power System	3 Years	Power Plant Design	2
B	Physics	30	B-ME 1949 ORSORT 1951	Completed 9 hours of graduate work	Electric Power System	4 years	System Operation	3
C	Mechanical Handling	43	BS-EE 1934 BS-Phy 1950 MS-Phy 1954	Took special courses in reactor theory during 1953-54	Electric Power System	20 Years including 3 years on loan to G.E. Co. (KAPL)	Power Plant Design	1
D	Instrumentation and Control	35	BS-EE 1949 ORSORT 1951	Took 20 hours of graduate work prior to going to ORSORT and has taken 10 hours since 1951	Electrical Manufacturing Enterprise	4 Years	Electrical Equipment Design	2

Atomic Research (Iowa State College) to study fission product separation.

3. We have found it to be entirely feasible to train engineers already at hand in the special knowledge needed for nuclear work. While this does not lessen the need for engineers in a company, it will provide the specialized training required now and until such time as this can be secured in the normal way in our universities.

The Detroit Edison Company has worked very closely with the Extension Division of the University of Michigan. During this past year, Dr. Henry J. Gomberg, Assistant Professor of Electrical Engineering and Assistant Director of the Phoenix Project, along with some assistants, presented extension courses in nuclear engineering in Detroit. These were very well received. When this training program was announced to Detroit Edison employes, it was thought that possibly 25–35 employes might be interested in this graduate course, Introduction to Nuclear Engineering. The course was described as follows:

> INTRODUCTION TO NUCLEAR ENGINEERING (Basie). An introductory treatment of application of theoretical physics in the production of nuclear energy, designed to develop a broad background in atomic and nuclear science. Text: *Introduction to Atomic and Nuclear Physics,* by Semat.

More than 150 Detroit Edison men signed up for this first course, but only 75 could be accepted during the fall semester. The course was repeated during the next semester and the second course—Nuclear Structure and Stability (Advanced)—was taken by about 40 employes. Of the 40 who took the second course, 18 have asked that the third semester's work be offered next fall.

An intensive desire to become knowledgeable in the new field of nuclear energy has been, of course, of tremendous assist-

ance in developing some of our electrical and mechanical engineers into nuclear engineers.

In this connection, it is of interest to study the academic and training backgrounds of four of the engineers holding positions of responsibility in the APDA group. Referring to Figure 1, we will select for this case history review the heads of the Fuel Element, Physics, Mechanical Design, and Instrumentation and Control Sections.

Analysis of the data presented in Figure 3 suggests that there are various ways of attaining competence in the field of nuclear engineering. Engineer A had no specialized training in the field prior to his joining APDA, while Engineers B and D attended the one-year course offered at the Oak Ridge School of Reactor Technology. Engineer C, some fifteen years out of school, developed an interest in physics and nuclear engineering. His additional schooling and the three years' experience at the Knolls Atomic Power Laboratory equipped him to perform his present duties very well.

Experience to be gained while on loan to one of the governmental laboratories is very valuable. Detroit Edison now has two engineers on loan to the Argonne National Laboratory. Another method of giving nuclear engineering training to men already established in the power engineering field is to offer scholarships. In this regard, Detroit Edison has an employe completing his master's degree in nuclear engineering at the University of Michigan and also has another taking a special seven-month course at Argonne National Laboratory.

Conclusion

In conclusion, we consider the peaceful utilization of atomic energy as one of the great new forces which will come into full use within the next two decades. An increasing part of new electrical capacity will be nuclear power, and new uses for what are now waste fission products will surely be found. This expanding industry will require an ever greater number of scientists and engineers to implement this program. We are confident that our colleges and universities working together with industry will meet this challenge successfully.

College Notes

The **New York University** College of Engineering has begun programs in nuclear engineering and engineering science this fall. The graduate nuclear engineering program, for which the degree of master of nuclear engineering has been authorized, is among the first in the United States. The engineering science program for undergraduates is directed primarily toward specialization in nuclear engineering.

In accordance with these new programs, a sub-critical nuclear reactor has been built with the Atomic Energy Commission's permission. This reactor, the first of its kind at a university, will be used for experiments in undergraduate and graduate laboratory classes in nuclear engineering. This reactor will be exhibited at the Atomic Energy Exhibition in connection with the Engineers Joint Council Congress on Nuclear Engineering to be held in Cleveland in December.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
JOHN L. ARTLEY, *Chairman*
Duke University

Editor of YET-itudes
LEE HARRISBERGER
N. C. State College

Lookin' Ahead

The Committee on Young Engineering Teachers is appointed under new management by the General Council each June. This year the CYET has set up another healthy and worthwhile program of real interest and value to every "youngster" in the business.

John Artley is this year's "boss" and is assisted by Tom Boyle, Assistant Professor of Mechanical Engineering at Michigan, as Vice-Chairman, and Lee Harrisberger, Assistant Professor of Mechanical Engineering at North Carolina State. John is Assistant Professor of Electrical Engineering at Duke, has been teaching six years, worked in industry a year and a half, and boasts of his three children (and wife). Since John is the "wheel," we asked him what's gonna make the wheel roll and he sez:

"The groundwork for a year of effective effort by the CYET was laid by Phil Weinberg at the annual meeting last June. The following recommendations concerning our activities were unanimously accepted by the General Council. It was recommended:

- That the CYET sectional subchairmen be elected at sectional meetings by the general membership. This would lead to closer cooperation between section officers and the YET subchairmen. The details of implementing this recommendation must be worked out through the proper channels. Until this is done we will continue to make up the committee membership by the 'will-you-volunteer' method used in the past.
- That the CYET be delegated to assist the Society in its membership drive. I hope each YET will take it upon himself to increase the effective membership of the Society. Effective membership should mean something beside paid dues and having a name on the roll. It might be well to have less of a membership drive and more drive within the membership. As a YET you have an excuse for being enthusiastic and vigorous. Get out and wake up some of the old engineering teachers. It is also desirable to contact persons in the service courses (Physics, Math, English, etc.)

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."
YET-itudes! Not Platitudes!

and interest them in the job we are doing.

- That the paper contest for YETs be continued and that notification of the rules be sent to all section chairmen and CYET subchairmen by October 1, 1955 for early publicity. An early announcement of the paper contest rules should help the slow starters. Here is an opportunity to tell your colleagues what you are thinking and doing about getting better engineers in action. If you have any worthwhile thoughts let us hear about them. If we haven't anything worth telling, why are we in the teaching profession?
- That a short term summer school be planned by the Educational Methods Division and CYET to precede the convention on a theme stressing pedagogical methods. There is a concern for a need of knowledge of the pedagogical aspects of engineering teaching. In addition to the proper scientific knowledge an engineering teacher should be cognizant of good teaching techniques and methods. Ed Kraybill, of the Educational Methods Division, suggested cooperating in planning such a session. We will work with him in this area.
- That a committee be appointed to study the feasibility of establishing an annual summer workshop for Young Engineering Teachers. This last recommendation carries the seed to answering many problems in maintaining and advancing standards in engineering education. You will be hearing more about this in future 'YET-itudes.'

You will be notified as to the progress of action concerning these recommendations. In the meantime, if you have any thoughts concerning CYET and YETs let us hear from you. Nothing like writing a letter or a paper to broadcast a good idea or gripe.

Engineering Education presents one of the most interesting challenges in our society. As Young Engineering Teachers we will be increasingly involved in evolving a pattern of education which represents progress. A vital aspect in effective progress of this nature is the communication of ideas and information. The CYET is an organized means for channeling such information. Use it!" . . . John Artley Chairman, CYET.

There are some fine things in store for the YET this year and notable among them is the planning for the first summer workshop for YETs! This is certainly going to be a wonderful opportunity. If ASEE is to ever do a great thing for its younger members, it will have its chance here. There is no one who needs concentrated study of pedagogical problems more than the YET. And every conscientious YET is anxious to become involved in such activity.

We would like to drop a big hint to all engineering deans and department heads looking in on this article, to wit: The guys who need to go to the ASEE workshops and the national convention, above anyone else, are the young engineering teachers. But very few do! Because it costs too much to pay it out of the personal pocket and the YETs are the least able to pay.

We are plugging for some thoughtful and positive activity within engineering college administration to start NOW to plan some way of getting their most promising young teachers to the YET summer workshop and the ASEE convention next year. We feel that every department has an obligation to itself and the YET to provide an in-service training program to insure better teachers and keep them.

It certainly would be a sound investment to see to it that at least one or two YETs from each department were sent to the YET workshop each year. Industry takes our half-trained graduates and give them extensive on-the-job training to make good engineers out of them. But, ironically, we expect our un-trained young teachers to become great educators with

absolutely no on-the-job training and no encouragement.

Engineering schools should REQUIRE that every young engineering teacher attend the ASEE workshops and conventions. They should regard it as a duty to perpetuate the quality of the staff. We always provide funds to keep the labs up to date and progressive. Why shouldn't we likewise provide funds to keep the faculty up to date? It's an investment! It should not fall within the hazardous category of travel funds (there is no fund that takes a budget beating like the travel fund). It should fall in the category of capital expenditures for modernization of the staff.

Let's get behind this thing! You can not have a summer workshop for YETs if they are all too poor and unprovided for to attend! Start some planning at your school to arrive at ways and means to get at least one YET to the workshop. If every engineering school sent only one YET delegate, we would have over 150 in attendance. That would be a real successful deal!—Lee H.

Here's your YET-itude for October:

Get out the lead, Ned! Plead the need!

College Notes

Rear Admiral Robert S. Hatcher (Retired) has been appointed director of the Guggenheim School of Aeronautics at the **New York University College of Engineering.** He also was named chairman of the department of aeronautical engineering, with the rank of professor. Until his recent retirement after 31 years of active service, Admiral Hatcher was assistant chief of the Navy's Bureau of Aeronautics in charge of research and development.

Admiral Hatcher succeeds Professor Frederick K. Teichmann, who has headed the Guggenheim School since 1945. Professor Teichmann will devote full time to his duties as assistant dean in charge of the Day Division of the College of Engineering.

Charles R. Anderson of Tappan, N. Y., has been named Director of the Division of Science and Technology of the Evening School of **Pratt Institute.** His Division is one of the three forming the Evening School of Pratt Institute, which began separate existence on July 1 of this year. It was formerly operated in conjunction with the School of Engineering.

The Use of Computers in Handling Statistical Data*

By W. W. BAKER

Engineering Department, Carbide and Carbon Chemicals Company

Introduction

Computation has developed out of measuring and counting, the two sciences being called geometry and arithmetic, respectively. A thousand years ago, the development of the abacus overcame the limitation set by the inadequacy of the number of fingers and toes a man could produce. Finally, hundreds of years after the development of the abacus, and thousands of years after the beginning of counting and arithmetic, great minds produced the little cogs which grew into modern adding machines, desk calculators, and accounting machines.

During the past few years, most people have heard of the remarkable devices often called the electronic brains. Every school boy knows that there are in existence some very complicated machines which are capable of outstanding feats of arithmetic. Some of these machines are more clever than others—able to do more kinds of problems. Some can solve problems that men cannot solve in hundreds of years. There are people who even consider an electronic computing machine to be capable of thought.

A general purpose computer is only a tool, just as a staff of persons at desk calculators constitutes a tool. If it is assumed that a staff has only enough intelligence and responsibility to carry out the simplest instructions and make the simplest decisions concerning the sizes of numbers, then all problems must be prepared as simple steps to be executed in sequence. The type of analysis that would be required to instruct such a staff is the same type of problem analysis that is needed for instructing general purpose computers.

The principles of modern computing machines are not new, even though electronic computers have been in operation only 11 years. More than 140 years ago, Charles Babbage dreamed of a machine that would add, subtract, multiply, and divide. It would also perform, automatically and without human intervention, a predescribed sequence of arithmetic operations and make predescribed logical decisions based on the results as it went along. In outlining his analytical machine, Babbage described all of the principles of modern digital computers.

Since the end of World War II, a number of computers have become available to industry. The first of these were produced primarily for business purposes, but it was only natural that modifications and developments would be made to these business machines to make them more applicable to scientific and engineering calculations. In more recent years, new types of computing machines have been developed specifically for scientific work. The majority of these machines are of the digital type; however, the analogue machine is becoming more and more important.

Types of Computers

There are two general types of computing machines. The analogue computer is

*Presented at the Annual Meeting of ASEE, Chemical Division, Penn State University, June 24, 1955.

just what its name implies: a physical analogy to the type of problem its designer wishes to solve. Information is supplied to the machine in terms of the value of some physical quantity. The machine transforms this physical quantity in accordance with the rules of its construction. A typical example would be an electrical network used to simulate a complex pipeline distribution system. The current flow would be analogous to the fluid flow and the economics of changes in the distribution system may quickly be investigated.

In comparing digital and analogue machines for simple problems, the analogue machine is almost always less elaborate. Even the most elementary digital computer requires an arithmetical unit, a control unit, a storage unit, an input device for basic data and instructions, and an output device for interpretation of results. In contrast, an analogue machine need be no more complicated than the problem demands. A slide rule, for example, is a perfectly respectable information machine of the analogue type.

As the problems become more complex, the analogue machine loses its initial advantage. Since it is a physical analogy of the problem, the more complicated the problem, the more complex the machine must be. Random electrical disturbances always occur in electrical circuits, and in the more complex analogue machines, these disturbances have an adverse effect on the accuracy of the results. This places a practical limit on the complexity of an electrical analogue computer. The digital machine is entirely free of such hazards. There is no intrinsic limit on the complexity of the problem that the digital machine can perform or control.

The third important difference between analogue and digital machines is their accuracy potential. The precision of the analogue machine is restricted by the accuracy with which physical quantities can be handled and measured. It is not uncommon to speak of accuracies of 1 or 2 parts per 100, but in the more complex units the accuracy may be much less than this. This is one of the more limiting disadvantages that analogue computers have in the field of scientific computations. On the other hand, a digital machine which deals only with discrete numbers can be as precise as the problem demands. When a result has more digits than places in the counter in a machine, "rounding off" must be done even in a digital machine, but the usual thing is for the result to contain more digits than are needed.

There is yet a fourth respect in which the two machines differ. An analogue computer works in what is called "real time," that is, it continuously offers the solution to the problem that it is solving, and this solution is appropriate at every instant to all of the information which has so far entered the machine. This property of working in "real time" is very important in most problems of automatic control. Some of the modern digital machines can achieve the necessary speed to work in "real time" for the control of aircraft, but they are not fast enough to deal with the problem of simulating the flight performance of a guided missle.

In simple applications, in which no great precision is required, an analogue computer will usually be preferable. For complex problems, or problems in which a high degree of precision is required, a digital machine is superior. Where "real time" computations must be made, analogue machines are almost always used now, though digital machines are beginning to achieve speeds to fit them for this type of application.

It should be obvious from the foregoing discussion that a digital type of computer is the most desirable for statistical and engineering applications. For a machine to be called a computer it must have five basic components: input, output, control, arithmetic, and storage. Even a desk calculator has these five.

Input

Input methods for computing machines vary with manufacturers. The input to a desk calculator is by way of the keyboard. The most common input to the automatic machines is the punched card. This form of input is especially desirable for accounting and business work because a single card can obtain all the information necessary about a purchase order contract, a storeroom item, a magazine subscription, and other similar information. In addition, punched card systems are especially adaptable for payroll work and general accounting problems, and they can also be used for scientific calculations.

Basic data and instructions can be read into some computing machines from perforated paper tape or from magnetic tape. The information is originally placed on the tape by a device that is quite similar to a typewriter. A typed copy of the data and instructions is made at the same time they are placed on the tape. This facilitates proofreading and checking. Generally, the speed with which information can be read into machines from the paper tape or magnetic tape is considerably faster than the input from punched cards.

Storage

The capacity of the storage unit and the access time to obtain the data from storage has been a major limitation in digital computers. Mechanical counters, similar to those in desk calculators, were first used; but recent developments have made the use of magnetic drums, magnetic tapes, and electrostatic storage practical. The availability of more storage capacity has greatly widened the field of digital computers. In the most modern machines, all of the basic data and instructions can be stored in the machine. The program is written in such a manner that it can utilize this stored information effectively.

Control

A control unit of a digital computer varies in type and style with the different manufacturers. Generally speaking, the more complex and advanced computers are far easier to control than the slower machines. Just a few years ago, it was necessary to wire individual control panels for each separate problem. It is now possible to code or program a problem for a computer at some remote location because the machines have built-in arithmetic commands or else they use general purpose plug boards. Most machines use what is called the three-address code. The first two addresses give the location of the numbers to be operated on, and the third address tells the machine where to store the result. The list of commands varies with each manufacturer, but always included are all of the standard arithmetic commands: input and output commands, some special commands, and certain "logical" commands to enable the programer to unscramble the stored data.

Arithmetic

The arithmetic units of modern automatic computers are always eletronic in nature. These units are so much faster than the other elements of a computer that it is difficult to utilize the full speed potential of a machine. Even so, high speed solutions are vital in a rapidly changing economy; greater speeds for our calculators will probably always be desired.

Output

If the input to a computer is a punched card, the output may then be a punched card or a printed scroll. If the input is a paper tape or magnetic tape, the output may then be a printed scroll, another tape, or an array on a cathode ray tube.

Advantages

Automatic calculators are expensive, not only in initial cost or monthly rental, but in upkeep in terms of keeping them busy. A machine earns no return when

it stands idle; in the case of a giant machine which may carry out instructions at rates of a million a minute or more, the problem of keeping it fed with problems can necessitate a staff of around thirty highly skilled people. Is such expense justified? To put it another way, what advantages do we gain from using automatic machines?

The primary gain, of course, is speed. This not only means that we can get our problems solved rapidly (i.e., before the solution becomes meaningless), but in many cases it means that through high speed we have the only possible way to solve a problem at all.

There are more International Business Machines' Card-Programmed Electronic Calculators (CPC) in service than any other computer. These are not fast machines, but they perform the arithmetic for the inversion of a 20-order matrix in about 8 hours. A 10-order matrix requires about 3 hours. This is quite long compared to some machines, but the CPC has limited storage and an excess of card handling is necessary.

The IBM Magnetic Drum Calculator Type 650 is a more advanced machine than the CPC and can do the same inversion about 10 times faster than the CPC. This is the result of a greater internal storage capacity. The elements of the matrix can be stored on a magnetic drum, and the machine can proceed with the computations with little delay.

If a large-scale computer is available with virtually unlimited storage and nearly instant access to the stored data, the speeds are almost fantastic. As an example, one machine can invert a matrix of order 31 with an input time of 4 minutes for the instructions and data; a calculation time of 4 minutes; and an output time of 10 minutes. Another machine can invert a matrix of order 15 in 1.2 seconds with only 19 instructions.

Together with speed, we get accuracy from automatic machines. In many problems, a single number is used many times; once entered into the machine correctly, the machine can be expected to repeat it correctly. Present machines are not absolutely perfect in this respect, but are very nearly so; at the least, they avoid the common human errors of miscopying.

We also gain in precision through using automatic computers, simply because it is no "harder" for a machine to carry eight digits throughout a calculation than it is to carry five.

A further gain is made in economy. One company, International Business Machines, produces a full line of computers, ranging from a small electromechanical type of machine up to the giant electronic computers. To illustrate, it might be fair to figure the cost of a single typical arithmetic operation on a desk calculator in pennies (say \$0.03).

The cost per operation on an IBM 602A or similar machine might then be one-tenth as much, or \$0.003.

The cost per operation on an IBM Card-Programmed Calculator (CPC) could be represented by \$0.0003.

The cost per operation on an IBM 704 or Univac Scientific might be around \$0.00003. These figures are relative only, and all assume full usage of the machine involved.

Statistical Applications

Probably an entire book could be written about the use of automatic computing machines in the solution of problems of a statistical nature. In fact, wide use of electronic digital computers has led to a revision of statistical methods. Much of the theory of statistics is, almost by definition, the characterization of large quantities of numerical information by certain indexes, of which the most common are the average and mean-square deviation. If the data can be placed on cards or tape, the reduction to a few statistics is often unnecessary.

Automatic computers permit statistical investigations where the work involved in manual treatment is not justified because of the low probability of gaining anything significant. An example is correla-

tions of scanty data, where normally one would hesitate to subdivide the sample into all the suggested categories. If a computer is available, it may be possible to find a trend or pattern at an earlier stage of the investigation, and subsequent experiment design can be made more effective.

The end point of most statistical experiment designs is a set of correlation equations. It is in this field that computers have been the biggest aid to the statistician. To obtain the correlation coefficient, many arithmetic operations must be performed. This number depends on the number of variables in the experiment and the number of levels that were considered. The result involves matrix multiplication and matrix inversion.

To illustrate how much arithmetic is required, if N is the order of the matrix, then $(2N^3 + 3N^2 - 5N)/6 =$ the number of additions and multiplications and $[N(N+1)]/2 =$ the number of divisions required for the inversion. Therefore, the inversion of a 20-order matrix requires about 3060 arithmetic operations. Unless it is a special case in which several of the elements are zero, a 12-order matrix is about the upper limit for desk calculator solution, and this is extremely laborious.

Computing machines are useful to a certain degree for the most simple statistical problems such as squaring numbers and then taking the square root of the sum of the squares. This becomes most attractive when a tape-controlled machine is available because its input-output speed is usually superior and a greater time advantage can be realized.

Automatic computers have made it possible to solve problems in statistics that heretofore have been considered impossible. The widespread use of these machines has actually caused a serious shortage of mathematicians and statisticians because personnel with training in these fields are best equipped to use the machines to the fullest advantage. Furthermore, the field of statistics has developed and broadened so much in recent years that industrial management is finally willing to accept statistical methods as a guide to decision.

One of the main factors in the expansion of the fields of mathematics and statistics has been the development of electronic computers. These machines make it possible to do more statistical work, in less time, at a more reasonable cost, and with greater accuracy and precision than has ever before been possible.

In the News

Joseph F. Hardee, former instructor in engineering mechanics at North Carolina State College, has joined the staff of the **Esso Research and Engineering Co.**

Cooperative Engineering Calendars*

By DONALD C. HUNT

Director of Coordination and Placement, University of Detroit

Continued progress and development for fifty years with tremendous strides in the past two decades is the history of cooperative engineering education. Indicative of this development is the growing recognition among industrialists that cooperative training provides an answer to the need for well adjusted and properly oriented engineers who can step into positions of responsibility shortly after graduation. The geographical spread of training assignments for students of each of the colleges has followed naturally, with the result that many large companies now have cooperative trainees representing ten to fifteen different schools. And this inter-relation of students from the several colleges has been in spite of different calendars, differing length work periods, and variations in the scheduling of training assignments in the plants.

At the Mid-winter Meeting of the Cooperative Education Division in Philadelphia in January, 1954, the industrial representatives made a request for a study of the variations in the cooperative calendars of the colleges. The thought was to bring the programs of the several schools closer together, and, as explained by industry, a more closely coordinated calendar among the several colleges would result in expanded and improved training assignments for all the cooperative students. This is now impossible because of the great variation in calendars.

This study is a result of this request. A calendar of the principal cooperative colleges follows, showing the current work schedule for parallel students. Each week is represented across the page, and the time between each work period represents time in school and/or vacations. As most schools follow a pattern of pairs of students, a student in the opposite section would follow a work schedule in the intervening weeks.

Conclusions

A careful study of these calendars and the reasons behind their planning brought about these conclusions:

1. Work periods of equal length are most desirable for industrial planning, and the vacation periods are the adjusting factors in making equal work periods.

2. As a three-month period provides the maximum that a student should be away from school, it follows that work assignments of thirteen weeks should be planned.

3. "Natural" breaks in the calendar provide the best time for rotating students, and the two most "natural" breaks are Christmas and Commencement. (Easter dates are too variable to be considered.)

4. An exact quarter system rotating approximately the fourth week of September, December, March and June is the most desirable.

5. Although variations of three to four weeks appear insignificant, it should be noted that in a thirteen-week plan the maximum variation is six weeks, and differences of more than one week are undesirable.

* Presented at the Annual Meeting of ASEE and accepted by the Cooperative Engineering Education Division, Penn State University, June 20, 1955.

WORK SCHEDULE FOR PARALLEL STUDENTS IN COOPERATIVE ENGINEERING COLLEGES — MONDAYS IN 1954-55

SCHOOLS | AUG. | SEPT. | OCT. | NOV. | DEC. | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY

WORK SCHEDULE FOR PARALLEL STUDENTS IN COOPERATIVE ENGINEERING COLLEGES
MONDAYS IN 1954-55
SCHOOLS
AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH APRIL MAY JUNE JULY AUG. SEPT. OCT.
LOUISVILLE 13 wk 13 wk
GEORGIA TECH. 13 wk 13 wk 13 wk
NORTHWESTERN 14 wk 12 wk 12 wk
DREXEL 14 wk 13 wk 13 wk
VIR. POLY. INST. 15 wk 11 wk 15 wk
MINNESOTA 14 wk 12 wk 14 wk
TENNESSEE 16 wk 12 wk 15 wk
EVANSVILLE 14 wk 12 wk 14 wk
MARQUETTE 13 wk 12 wk 14 wk
FENN 13 wk 12 wk 13 wk
DETROIT 13 wk 13 wk 13 wk
ANTIOCH 10 wk 16 wk
G.M. INST. 4 wk 4 wk 4 wk 4 wk 4 wk 4 wk 4 wk 4 wk 3 wk 3 wk
CINCINNATI 10 wk 8 wk 8 wk 11 wk
NORTHEASTERN 16 wk 10 wk 16 wk
AKRON 11 wk 10 wk 10 wk
M.I.T. 20 wk 14 wk
ILLINOIS TECH. 20 wk 8 wk
CORNELL, DELAWARE, AND SOUTHERN METHODIST have a program on a semester and summer basis with S.M.U. breaking the semesters into two eight week periods. The exact dates for these schools were not available.
Prepared by: DONALD C. HUNT
UNIVERSITY OF DETROIT
JUNE, 1955

CHART 1

6. The request of industry for a coordinated calendar among the colleges is reasonable and sound if we are to expect continued improvements in the training programs provided for cooperative students.

7. A failure to recognize the request would be extremely impolitic as the request has come from the "customers" of cooperative education.

Recommendations

It is recommended that: (1) an exact thirteen-week quarter system rotating at Christmas, similar to the 1954–55 calendars of the University of Louisville and Georgia Institute of Technology, be adopted as the ideal calendar; (2) the member colleges attempt to arrange their calendars accordingly, with a variation limit of plus or minus one week.

Note: (1) The above chart is arranged progressively, with the schools most in line with the above recommendation at the top and those the least in line at the bottom; (2) Nine colleges indicated that changes in their calendar could be made and ten indicated that changes could not be made. However, six of the ten "no's" were from schools not now operating on a "quarter" system. There was no reply from two schools.

College Notes

The School of Engineering, **Louisiana Polytechnic Institute**, Ruston, Louisiana, will serve as the meeting place of the Fourth Annual Instrumentation Conference on November 3–4, 1955. The tentative program will include papers on the following subjects or about the following fields: Instrumentation and Control of a Large Power Plant; Instrumentation and Control of a Compressor Station; Practical Applications of Industrial Flow Colorimeters; Butterfly Valves; Instrumentation in Catalytic Cracking; All Electric vs. Pneumatic Instrumentation; Aluminum Industry; Paper Industry. All interested parties should contact the Instrumentation Conference Committee, School of Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana.

COLLEGE–INDUSTRIES CONFERENCE

MARQUETTE UNIVERSITY

January 25–26, 1956

The Art of Writing

By JOHN H. BOLTON

Editor, Iowa Engineering Experiment Station, Iowa State College

The expression of idea, whether it be in painting, music, sculpture, writing, or plan and design of a machine or a structure, is an evidence of the personality of an individual. Each individual expresses his ideas in his own peculiar way, and each is identifiable by his expression.

A Beethoven composition, an Innes painting, or a Frank Lloyd Wright building can easily be distinguished; and the works of the lesser known artists are quickly recognized by any one who is familiar with their work. Each stamps his "trademark" on his production. Because a writer shows his individuality clearly in his work, he can be identified even more easily than other artists in their productions. "I knew you had written that," one is told, "it is just like you." Teachers soon learn to distinguish the copiers and cribbers in their classes. And an editor rarely fails to discover plagiarism, simply because writing points out the writer so plainly.

We have had much instruction in the technique of writing. Many authorities have told us how to write, how to use words and sentences. They have told us how to construct paragraphs and how to outline our ideas for clear and logical expression. We have been recipients of information on how to present ideas graphically by charts and diagrams. We have been told how to prepare tables and all the other aids in expressing ideas. The time-worn expression that a picture is worth a thousand words has been drummed into our minds until we accept it without much thought.

All of that is true, without a doubt. But without another concept of writing our productions remain without a soul, uninspired, and very dull. The additional concept which requires the fullest appreciation is that writing is an art. It is not a science. There is very little beyond the basic grade school rules which can be called a science, if we limit our idea of science to the following of rules. It is unfortunate, but you will find that most of those who say that writing is an art soon fall by the wayside and try to treat writing as a science. Little wonder that students and even professional writers have difficulty in expressing themselves.

On Simplicity of Expression

Just as the greatest painting is the simplest, the best writing is simple in the way in which ideas are conveyed to the reader. All ideas cannot be simple, but most complex ideas can be expressed fairly simply. Involved phrases, clauses, and sentences add to the difficulty of understanding and are certainly not the best art. Abstruse and complicated language is not necessary for the expression of any idea, no matter how technical it may be. Every one tends to express a complicated idea in involved language; but he must, if he desires to have his ideas understood, say what he thinks as simply as he can.

Men in management positions soon learn that it is often necessary to rephrase complicated ideas and put them in simpler language if they are to be understood by their workers, whether factory laborers or technical men. The ideas in most textbooks are rephrased by teachers as they instruct a class. And, may we note here, without any intent of criticism,

that most college professors instruct classes in simpler language than that which they use when writing their textbooks. It is quite normal that they should. Oral expression of idea in instruction is naturally simpler than written expression because a speaker has his students before him and is therefore aware of them. He intentionally adapts himself to the level of understanding of his hearers. But a writer is not made to adapt himself to any level of understanding because his reader is not present when the words are set down on paper. Of course he jolly well should have his reader in mind when he writes, but quite often he does not.

A writer may argue that if he expresses himself simply he will not be credited with knowing as much as if he expresses himself in longer, more involved fashion. That may be true for those few people like himself who expect ideas to be couched in hazy, rotund verbiage. But those who are really expert in a certain field of knowledge express themselves in simple terms. It is noteworthy that usually the more a man knows, the simpler the language he uses to express his ideas. And these men are usually much more interesting than those less informed. Their complex-knowledge is through some metamorphosis expressed in easily understood terms. The reasons for this are two in number—first, the greater authority a man is, the less he needs to impress others; second, the more he knows, the better his insight and understanding.

On the Use of Rules

Every artist must have a knowledge of the rules which are fundamental in his art; but he learns quickly that rules are for guidance, not blind observance. Those best informed in any art—the critics and the teachers—are usually poor performers. Most art critics have never produced a sketch nor painted a picture. Almost every community in the nation has music teachers who, though they never perform themselves, present fair to excellent annual concerts given by their pupils.

The rules which a critic must know thoroughly, and which a teacher instills in the minds of his students, make the critic and teacher so "rule conscious" that they are usually not even third rate artists. Rules are valuable as guides, but one will never become a successful artist in any field if he slavishly follows the sign posts. This is certainly true of writing.

A reading of the publications and the usual textbooks on the subject of writing convinces one that the authorities are treating writing as a science. If every writer followed the teachings of the experts in the field, their productions would have a deadly sameness. All writings would be a stilted following of the rules and little more; for the rule makers and teachers set down exact techniques for handling every problem one faces in writing. If a writer attempts to follow those rules without thought, as many do, he fails miserably in expressing his ideas. Luckily the individual usually expresses himself rather well in spite of the experts; but too often he attempts to follow the scientific path and winds up in failure.

Of course one should follow the rules, but not blindly. For instance, every sentence must have a verb and a subject. What nonsense! Any artist in writing knows that "what nonsense" as used in the preceding is just as good as a sentence having a verb and a subject. One must consider writing as an art and strike out on his own if he desires to be successful in getting his ideas to others.

Until a writer is able to consider rules and the so-called science of writing as general, not absolute guiding principles, he cannot be a good writer. Until then he will subordinate the expression of his ideas and his personality to the following of regulations. As a result his writing may be technically correct; but it will be quite ineffective, and certainly uninteresting.

On Writing for Others

To re-state what has been implied up to this time, when one is learning the art of writing, he must also learn how to write so he can be read and understood. No artist of any consequence produces his work for himself alone. He attempts to reach the understanding and appreciation of others. The true artist knows there is no lasting satisfaction in producing for himself, but the writer who attempts to follow writing as a science never becomes an artist.

Much writing on scientific subjects is so unnecessarily involved and difficult to understand that few read it easily. This writer is certain from his survey of textbooks in science that much of the difficulty for the student-reader lies in the ineptness and the carelessness of the writer. Writings on scientific subject matter too often show the "public be damned" attitude of the writer.

Little of engineering is highly scientific, comparatively speaking. For that reason, much of the difficulty found by students of engineering is probably that freshman and sophomore texts are written by specialists who write on the college senior and post-graduate levels. Many authors do not seem to know that college students grow mentally from year to year. And none of these authors, if he were a coach of athletics, would expect every runner to break the four minute mile mark. Nor would he expect every football player to make a touchdown every time he carried the ball. But the freshman too often is expected to understand the same level of writing as the third or fourth year college student. There is little consolation for the student in this, but there is a lesson for every writer. He must have his expected reader audience in mind at all times.

On Determining Readability

Since writing is not a scientific following of rules but an art, no exact and absolute method has been or is likely to be developed for determining the ease with which a writing may be read and understood. No attempt at setting up such a standard has met with the full approval of any expert in the field of writing, so far as this writer has been able to determine.

The most widely publicized scales have in common the determination of difficulty of vocabulary plus the length of sentences. Such scales fall down because a word which may be a difficult word for one reader is not at all difficult for another. Simple one syllable words like "life" and "love" will give even a philosopher pause, and words like "trafficability" will not stop a soils engineer for a moment. A long sentence may likewise be difficult for one reader to understand but not for another. Compromises have resulted in very involved scales which have been heralded as complete answers to the problem. They are not at all answers to the involved problem of determining just how difficult a writing is for a reader to understand.

One fault with scales for finding readability is that the writer who does not know that he is dealing with an art accepts the "scientific" scale as an absolute and infallible answer. The chief fault, however, is that the originators of such scales do not accept writing as an art. If such scales were published as indications of readability and were accepted only as indications, we would have less objections to them. Writing is not an exact science but an inexact art which depends both on the personality of the writer and on the individuality of the reader for effectiveness.

A few years ago a simpler scale was developed which makes little pretense of measuring readability exactly.* The originator says that his scale indicates the difficulty of writing rather than determines it exactly. In the comparison of results obtained by this scale with the results of other scales which make claims for exact-

* Robert Gunning, "The Technique of Clear Writing," McGraw-Hill Book Co., New York, 1952.

itude, a close correlation has been found. The simpler scale is recommended to any writer who wishes to see how readable his work is. Reduced to its essentials the scale is as follows:

1. Determine the per cent of words of three or more syllables, "hard words," in the writing.
2. Determine the average number of words per sentence, counting each main clause in a compound sentence as a separate sentence.
3. Add the per cent figure and the average number together.
4. Multiply the result by .4 (four-tenths).

The result of adding apples and oranges together and multiplying by bananas is called a "Fog Index," which gives an indication of the difficulty of any writing. We do not defend this empirical method or even attempt to explain it, but we are convinced that it works. A score of nine (which corresponds to ninth grade level, if you wish to use such a comparison) indicates quite easy reading. A score of sixteen indicates college senior level, which is perhaps the absolute maximum any writing should reach. Fourteen is the more desirable limit.

Too low a readability score is an indication of galloping. For this effect read critically *Ladies Home Journal* or *Coronet,* to mention only two with scores of 7 and 9, respectively. Too high a readability score makes the assimilation of thought too much work. That is the reason why nineteenth century literature, as exemplified by the novels of Thackeray and the prose of Matthew Arnold, is no longer the popular reading of housewives and business men. Then, if you really want to work, go back to Francis Bacon and like writers in seventeenth century literature. Their writings are full of excellent thought, but much too difficult for modern taste.

A writer can easily find the readability of his work. If it is on too high a level, he can help his reader by using more short sentences and fewer lengthy words. If the readability is too low, he can combine simple sentences and make main clauses into modifying clauses or phrases. He can also choose shorter, more common words instead of longer unnecessarily technical words. Even an extremely scholarly treatise does not *have* to be difficult reading. The author has it in his power to make his writings as easy or as difficult as he desires.

Saving Time Is Important

In this day of the great flood of publications which all of us should read, the saving of time is important. A college graduate can read and understand an article more quickly if it is on the 12 to 14 level than if it is more difficult. If we have a choice, all of us select for reading the articles which are easier to comprehend. Of course special interest in a subject will lead us to choose some writing which is difficult to read, but what a relief it is to find articles which combine reader interest and moderate readability.

Consider the following selection in which only a small per cent of readers will find any natural interest. This is from the publication of a general (not specific) scientific society in England:

"Mr. T. J. Heal (Fulmer Research Institute) gave a critical evaluation of the reliability of the atomic distribution curves for liquid metals as obtained by x-ray diffraction methods. In this work the effect of incoherent scattering and scattering from atomic structure, which afford the principal contribution at large sin ϕ/A, is subtracted from the observed scattered intensity, and the residual pattern is analyzed to give the atomic distribution as a function of distance from a central atom. Errors arise from x-ray absorption, from uncertain calibration of film intensity measurements (particularly when two different radiations, usually those from copper and molybdenum targets, are used to study the same material), and from integrations over finite limits in obtaining the Fourier transform of the scattered intensity."

The average of words per sentence is 42 and "hard word" percentage is 30, which results in a Fog Index of 29, fifteen points higher than the suggested maximum for any writing, or thirteen above the absolute maximum. In justice to this publication, the sample is not typical of the whole report, which scales around 16, or two points too high. But it is no wonder that the research professor to whom this periodical goes finds little of interest and skims rapidly through the publication to find items of special interest to him.

Nor are English publications the worst offenders. Here's a selection from the output of one of the big companies in the United States:

" . . . The shutters also would stick or freeze shut under snow, sleet, or dirt conditions or when the shutter blades were bent enough to cause excessive friction at the fulcrum pins. The third basic fault was that, combined with the necessity for heating all of the coolant in the system, initial engine warm-up was excessive due to air leakage past the shutter blades.

"Because of the shortcomings of the thermostatically controlled shutters, research and developmental work was initiated by automotive engineers in an attempt to eliminate the shutter-type coolant temperature control and to perfect a suitable cooling system thermostat which would provide adequate coolant temperature control for car heating and satisfactory engine operation."

Whew! Yes, that is it. Three sentences, 38 words per sentence and 17% hard words. Fog Index 22, or eight points above highest advisable. No wonder one has trouble reading some external company pieces. Again this is not entirely typical, but the Fog Index on the whole article is 19, or five points above the highest desirable score.

A moderate sized company with which we are well acquainted has an external publication which regularly scores above 18. Since little of this manufacturer's product goes to college graduates, one may conclude that he is wasting both time in preparing such a piece and money in producing it. We wonder how many of the potential readers find any interest in a magazine on such a high level. Though it is presented in an interesting and attractive format, probably few copies are kept for reference by the recipients.

Professional writers could learn much from the advertising in the same publications in which their work appears. In a random check made recently the advertising in three technical periodicals had a readability of between 9 and 11, while the articles scored from 15 to 17.

The general impression from checking publications of the scientific experimental groups throughout the United States is that with few exceptions they scale only slightly above the optimum in difficulty, but about the maximum advisable, around 15 Fog Index. The research on readability indicates that when a writer is telling what he did, he uses a simple, readable style. When he explains why he did it, he gets into a more difficult, less readable style. That these publications are easier to read than the technical journals is probably because the research men usually take more time in their writing and do more revision. It also could be that most experimental organizations have fairly well qualified editors who assist in the writing.

Writing is an art, and the writer can develop proficiency just as any practitioner in any art does, by practice and more practice. Who knows but that in some future time such repetition will lead one to enjoy expressing ideas in writing. We think it worth trying. Don't follow rules blindly, but develop the art of writing and enjoy it. Keep the rules in their proper place; and do not let them interfere with the clear, easily understood expression of ideas.

Teaching Basic Electric and Magnetic Fields —A Challenge!*

By SAMUEL SEELY

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1. *Introduction*

The presentation of electric and magnetic fields to undergraduate students at the sophomore and junior level has long been a challenge to engineering educators. The difficulties in presenting this material arise from the rather tenuous character of fields, and from the mathematical demands on the student. The student has had little prior experience with fields, and to help him develop the degree of sophistication required for an understanding of field concepts in a single course often imposes considerable demands on the teacher. The student is being asked to mature rapidly in his physical understanding and perception, and also in his mathematical dexterity. This imposes considerable demands on the student.

The traditional approach to the study of fields follows from a discussion of a number of experiments which may be conducted or imagined. These are fundamentally measurements of force, and may be accomplished through the use of a torsion balance, an invention of Coulomb. Many of the fundamental experiments may, and should, be performed in the laboratory by the student. The development of the appropriate theory follows as a formulation in mathematical terms of the experimental results. This is a perfectly reasonable sequence and it is the sequence that has been developed by educators during the past half century or more. It will be shown here that an alternative sequence is possible. This alternative sequence also has its roots in experiments that the student may perform readily in the laboratory, but it is felt that this new sequence possesses certain pedagogical advantages.

2. *The Classical Approach*

The basis for the discussion of the static electric field is to be found in Coulomb's law, which expresses an experimental result in mathematical form. Implicit in Coulomb's law is the concept of "action at a distance" and the mechanism by which the force due to one charge is exerted on another charge is the electric field produced by each charge. Clearly, Coulomb's law may be considered to show that the interaction of static electric fields produces forces. Ordinarily, the preferred interpretation is that one charge in the electric field of another charge, or of a charge distribution, experiences a force on it. This leads quite naturally to the definition of the electric field intensity at a point in space as the force per unit charge at that point.

The theory develops by deducing expressions for the electric field intensity of a variety of charge distributions: point, line, surface, and volume. The results are physically general, but, mathematically, the vector integrations cannot be carried out except in a few special cases. Hence, it is necessary to continue with the development of the theory along different lines.

From considerations of the work done

* Presented at the Annual Meeting of the American Society for Engineering Education, Pennsylvania State University, June 22, 1955.

in moving a charge in the electric field, the concept of difference of potential is introduced. From this, one may introduce the absolute potential at a point, and then the notion of equipotentials, and the potential map of the field. A discussion of the potential gradient and its relation to the electric field, and the significance of the line integral follow quite logically.

While this classical development proceeds quite logically from physical experiments and reasoning, it proves to be a difficult and confusing one to the beginning student. To see more clearly why this is often so, let us review the situation. One begins with a physical law or postulate concerning the production and consequences of a field, or the interaction of fields. This is a vector relationship. The students have encountered vector quantities in their prior work in mechanics, but in a limited way. The difficulties encountered in working with vector quantities, particularly with the vector integrations involved in determining the electric field intensity of a continuous charge distribution, must be discussed. With a view toward simplifying the subsequent development, but in a manner which appears to the student as little more than some mathematical hocus-pocus, one introduces a scalar potential, the negative gradient of which is the electric field intensity. Now to add to the "clarity", the term "conservative field" is introduced, words which ordinarily, carry no connotation to the student. And then to make the situation still more lucid, the "line integral" is introduced. In this way, the entire study of electrostatics has been presented to the student. That he doesn't really understand and appreciate the subtleties of what has transpired is not at all surprising. Much of the difficulty, it is felt, stems from the fact that too little is said about the field itself, even though the student may carry out the integrations involved in the expressions that have been developed from general considerations. As a result, such problem-solving fails to clarify the fundamentals of the situation.

3. *A Suggested Approach*

A fundamental question is the following: "Is it possible to introduce the subject of electric and magnetic fields to a beginning student in such a sequence that the physical and mathematical concepts proceed from the simple to the complicated (that is, from the scalar to the vector), rather than in the reverse order?" That is, is it possible to proceed from (a) a study of the physical aspects and characteristics of a scalar field distribution, to (b) a discussion of the potential distribution in the field, then to (c) considerations of the gradient of the potential; to (d) a discussion of the work expended in moving a charge in the field, and finally to (e) the vector properties of the field itself? Fortunately, such a sequence of logical presentation is possible, and it is the experiences of Dr. Edward Erdelyi and myself at Syracuse University in presenting the study of fields in this way that I wish to discuss now. Actually, the approach to the subject is that suggested in the book, *"Einführing in die Theoretische Electrotechnik,"* by Karl Kupfmuller.

The development proceeds from considerations of the "current flow" field. This is accomplished by discussing experimentally determined flux plots, and such flux plots are obtained by the student himself in the laboratory with either commercially available flux-plotting equipment, or with locally produced equipment. This has the advantage that the student begins his study by plotting and exploring scalar fields distributions. Moreover, the concepts of equipotential lines and surfaces, and of flow lines, now become a personal experience.

The introduction of such mathematical concepts as: difference of potential, potential gradient, and line integral, proceed quite naturally in translating the observed aspects of the field into mathematical notation. The introduction of the "electric field intensity" proceeds as a definition,

as the negative of the potential gradient. The bulk properties of current and current density proceed with little difficulty, and the water flow analogy serves to provide the understanding of the current flow field. Ohm's law in field terms follows simply, but some word about its significance must be added. A general relationship for resistance follows with no difficulty. Clearly, the focus of the student is on the field, with the mathematical description following therefrom.

With the foregoing background, it is now possible to introduce the vector-analysis concept of the scalar product of two vectors, and to relate the current with the surface integral of the current density and the vector element of area (this latter must first be discussed). The first Kirchhoff law in general form is readily discussed in terms of an incompressible fluid flow, or as a conservation theorem. The second Kirchhoff law is easily related to the line integral in the field.

A variety of very interesting flow field problems are now possible for the student such as: flux plotting of a variety of field configurations, calculation of resistance from the flux plot of any specified electrode configuration; flow fields of point sources, of concentric spheres, and of spherical conductors; of line sources, grounding rods, coaxial systems, and the ground resistance of imbedded electrodes. Also, the method of electrical images is made entirely plausible from the known behavior of the current field.

4. *General Observations*

It has been our experience that work on the current flow field, with all that can be deduced therefrom, proceeds slowly. Moreover, the required mathematical manipulations still remain difficult problems for the students. However, it does seem that the students obtain a fairly good grasp of the basic field concepts, as well as the capacity for approaching intelligently problems that require an understanding of the field concept.

The subsequent work in static electric fields proceeds very rapidly, since the students are quite familiar with virtually all of the features of such electrostatic fields. Virtually the only new idea is the concept of force, that is given by Coulomb's law, and this introduces no fundamental problem in understanding. The examples of flow field problems almost make Gauss's law a trivial new concept. Similarly, their prior work on power loss provides background for understanding the idea of the energy stored in the electric field. The discussion of conductors, insulators, and capacitance, and the discussion of the mechanical forces in the electric field require some new ideas, but these seem to proceed with little difficulty.

The studies of stationary magnetic fields, magnetic effects of iron, energy and mechanical forces in the magnetic field, electromagnetic induction, and Maxwell's equations, all benefit from the student's familiarity with fields, and the mathematical representation of the field quantities. In fact, the introduction of the divergence operation and the Divergence Theorem, and the curl operation and Stoke's Theorem, at the appropriate points in the course, seem to proceed without particular incident. Nor, in fact, do Maxwell's equations in vector form seem to produce any mental block in the minds of the students.

5. *Conclusions*

In summary, therefore, it is noted that our experience with the study of electric and magnetic fields through the initial introduction and careful experimental and anlytical exploitation of the multidimensional current field shows this to be a very effective means for the presentation of field problems. The student seems better able to understand and appreciate his subsequent work than he does if the material is presented along the more traditional lines. It is noted that, while his grasp of the physical ideas is greatly improved, the mathematical complexities and difficulties remain roughly as before.

High School Science Fairs in the Fields of Mathematics and Physical Sciences*

By WATSON DAVIS

Director, Science Service, Washington, D. C.

If we are to keep civilization supplied with the technical and scientific talent necessary to a free and safe world, constantly advancing, we must discover, develop and nurture our youth showing interest and capability in science and engineering. We are engaged in a long-continued struggle between the freedom of democracy and the tyranny of autocratic communism. Democracy needs scientists and engineers to remain dominant in this struggle.

Under orders, Soviet youth are forced to become engineers and technicians in greater numbers, we are told, than our democratic educational system without duress produces technically trained personnel. Without resorting to the methods that we are confident will eventually ruin the fruitfulness of Soviet technology, America must increase the flow of its talented youth into the fields of mathematics, physical and other sciences and engineering so necessary to our future.

Experience has shown that the place to begin is as early in the high school as interest can be captured and implemented. The science club and the science fair are prime devices for doing this. Reading about science in newspapers, magazines and books, or hearing and seeing it on radio and TV is spectator science. So, unfortunately, is much too much of our science teaching. You must actually play science to understand it and appreciate it. It is, admittedly, more difficult to participate in science than to just read about it.

It is terrifically important that many of us have actual experience in science. This can best be done during the school years. For this reason in the interpretation of science, the science clubs, largely conducted as an adjunct to the secondary schools, take on such importance. In the science clubs many who otherwise would not have an experimental acquaintance with science have this satisfying opportunity. Over the years millions, who do not and should not become scientists and engineers, experience science as a hobby, to their personal benefit and to the enrichment of our national policy.

The science youth movement (for that is what it is) has the other important function of allowing the discovery of those boys and girls capable of being the scientists and technologists of the future. The young person with talent often discovers himself through the excitement and satisfaction of tackling a scientific problem experimentally.

What grass roots are to agriculture, science clubs are to science education. These bands of boys and girls are a perpetual youth movement, constantly renewed by the innate and undulled curiosity and exploratory spirit of those who are discovering, through doing, the world about them. If the future belongs to youth and to science, then there is a vastly more important place for science clubs in the scheme of things that are to be. Except that it is now given purpose, aid and encouragement through tools and programs, this ganging-up of those who want to find out

*Presented at the Annual Meeting of ASEE, ECAC General Session, Penn State University, June 23, 1955.

about nature, machines and stuff is not a very new phenomenon.

Boys have had their workshops in barn and basement. In pioneer American days the whole struggle for existence was one big experiment and the children played their early and practical part in it. Girls, too, are no new hands at this business of experimenting, except that during certain decades getting feminine hands dirty was not fashionable. But there was always the tomboy, at that.

Today it is recognized that science education must be accelerated if our growing boys and girls are to recapitulate the scientific history of the human race in the few years between entering school and getting to or through college. The formal science classes in grade, junior high and senior high schools do their part; it is a large share, too, if the pupil is fortunate enough to have a well-informed, enthusiastic and tolerantly skeptical teacher.

The informal science clubs, squeezed in after school with the help of a teacher-sponsor, or the equivalent gang that makes models, or builds a radio set, or does chemical experiments, or collects insects, getting together in the precious free time left after school or on Saturdays and Sundays —these groups have quite as much educational value and purpose as the 9 to 3 (or whatever it is) schedule. We used to hear a lot about leisure time activities, and I used to wonder how that sounded to these boys and girls who are always busy and never have time to do all they wish to do.

The "grass-roots" of science understanding is the typical club or group in a high school in some town or big city. Science is the hobby as well as the study of each boy or girl among the 20 to 30 members. A teacher who likes science, as he enjoys teaching youth, is the "sponsor." During noon hours, in class time, after school, on Saturdays, the science club members work on their projects—investigations of varying degrees of difficulty, originality and importance. The whole range of human interest and science is spanned—everything from astronomy to zoology—inventions, aids to health for the neighbors, insect collections, study of rocks, building of mechanical models, raising of animals, weather observations, food tests, chemical experiments, and thousands of other projects.

Some of these are scientists of tomorrow—and all are the citizens of tomorrow who will use and understand science. For the future of America—for peaceful living, for industrial progress, for a successful democracy, for a strong and prepared nation—this quest for science understanding must be expanded.

Great Movement

The foundations of this great movement have been built in the youth activities of Science Service's Science Clubs of America. There are more than 15,000 affiliated clubs—in every state—and almost every county, city and town of the land. A third of a million members are on the rolls of these clubs. State science academies, colleges, teachers associations, museums, newspapers, and other organizations are cooperating. In 38 of the 48 states, there is major cooperation as a part of the Science Clubs of America development.

The National Science Talent Search for the Westinghouse Science Scholarships is now in its 15th year. This is a nationwide selection of the high school seniors who are most likely to be creative scientists of the future. The selections are made through a vigorous competition based upon results of science aptitude examinations, recommendations, evaluations and science project reports. In all, 4,200 boys and girls have been picked for honors, and the National Science Talent Search has been extended into the states through the utilization by state committees of the entries for further honors.

The Science Talent Search, a Science Service activity, has pioneered the recognition by the educational and scientific world that those with talent can be picked successfully at the high school level.

The work of science clubs is culminated

in science fairs now held as part of the science club movement in about 100 localities. Science fairs attracting up to 1,800 entries, in some cases, are held annually. Newspapers and educational institutions cooperate in sending finalists from these affairs to the National Science Fair, a Science Service activity. The seventh such event will be held in Oklahoma City, in May, 1956.

Future scientists and engineers can be "spotted" about nine times out of 10 by local judges anywhere in the United States by the time the students are sophomores in high school, perhaps much earlier. But whether these boys and girls go on to realize their career potential depends in large measure on how much their community has encouraged them and will continue to guide and stimulate them.

An experiment in home town cultivation of scientists and engineers has been going on for six years through the National Science Fair, conducted annually by Science Clubs of America, administered by Science Service. In 1950, 13 communities held local science fairs and selected their best sophomores, juniors or seniors to compete in the First National Science Fair. This year 71 regions from coast to coast held affiliated science fairs. Each fair names one or two of its best as finalists to compete at the National Science Fair. This year 136 competed at the Sixth National Science Fair at Cleveland.

Stemming the scientific manpower shortage has become a cooperative grass roots operation. Educators, scientists, engineers, colleges, universities, industries, technical and civic societies, newpapers, and countless other agencies in each locality have pooled their resources and know-how to find and help the youngsters who will be tomorrow's research and technical manpower. Their skill at doing this has become so expert that it can be predicted that up to 88% of the 14- to 19-year-olds they send to the national competition will actually go on to make science or engineering their career. Many thousands of other boys and girls, too young to be sent to the national competition, or who missed it by a narrow margin, will also go into careers that will build up our pool of urgently needed scientific manpower.

Recently the 248 young people (156 men, 92 women) who were named as finalists in the first five National Science Fairs were asked to give information about themselves. Of 85% who replied, 131 were in college or other institutions of higher learning, attending 83 institutions in 28 states, 58 were still in high school, 12 were in full time employment, eight were in the armed service, and four are devoting full time to homemaking and child care. Some career choices of the 131 college students are: 41 in physical science (chemistry 27, physics 13, biochemistry 1), 31 in engineering, 28 in biological sciences and medicine, 13 in miscellaneous science, and 10 in miscellaneous non-science.

This is the picture at the culminating national science fair level. In every part of the nation a similar rise in interest in science and technology is on the march, thanks to youth, teachers and adults who realize the need of this science youth movement.

This is assurance of future national strength. The people who think, reason, discover and apply in freedom will win the future.

Aim for Ames in 1956

Risk Analysis in Engineering Economy Studies*

By F. A. GITZENDANNER

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The object of this paper is not to describe a new concept or mathematical development. Rather its purpose is to describe some of the ways we have found it helpful in our business to use the concepts of game theory, statistical decision theory and perhaps some other names for the same general area of study. Another purpose is to suggest that such uses are properly a part of Engineering Economy and should be incorporated into the discipline.

Many engineering choices are between alternatives about which there are insufficient data and many uncertainties. Typically a low-cost alternative may be successful. However, it may fail and a higher cost step must then be used. In that case, the amount spent on both alternatives will be more than had the more expensive, and normally more certain, course been selected in the first place.

In a commercial problem, the alternatives available usually include several possible steps along quite different paths. As a result, the problem rapidly becomes very complex. Complexity alone is not insurmontable, but ways are not generally understood for handling the inherent uncertainties.

Over the past 20 years much has appeared in the literature, under various names, addressed to such problems. Our major task in trying to put it to use has been to select pertinent concepts from the technical literature and apply them to real problems. The outstanding difficulty is to devise ways of modifying the highly artificial and arbitrary conditions surrounding the game or illustration to the quite different circumstances surrounding real problems. This, incidentally, has been a far greater task than mastering the technical and mathematical concepts in the first place.

As a basic example, consider game theory which at first look appears to be the way to handle problems of low-cost versus high-cost alternatives. Game theory assumes that one's opponent is intelligent and governs his actions, in response to ours, to help his aims and hinder ours. But in engineering problems, no such condition exists. Nature is not perverse. We are merely ignorant of the true situation and therefore of the outcome of our action. This aspect, the fact that the problem of n-person games is not yet worked out and similar situations in other areas left us without a clear method for handling our problems.

A process of modification and adaption from the broad field of statistical decision work was used. This has finally resulted in what we have called a method of risk analysis. This name seemed to describe what we were doing and was free of the objections made to some other names.

Now rather than continue in generalities, I'm going to discuss specifically how we handle some typical problems.

Illustration

For purposes of illustration, I will discuss a problem which we had to decide. You are all familiar with the large storage tanks found around refineries. The particular tank in this case was 120 feet in diameter and 50 feet high and would

* Presented at the 63rd Annual Meeting of ASEE, Engineering Economy Committee, June 23, 1955, Penn State University.

hold about 3,500,000 gallons. The refinery where it was located is situated in hilly country and the storage tank areas require horizontal terraces to be excavated in the hillsides to provide the necessary level spaces. It is customary in connection with such tanks to fill them with water in order to test for leaks before putting them into petroleum service. In this particular case, approximately ¼ of the foundation area under the tank settled excessively during the initial water test. This happened despite the fact that all normal engineering studies which were made prior to the erection of the tank indicated no reason to suspect that this excessive settlement would occur. The tank was not damaged by the settlement of the foundation but was unsafe for service in that condition and the foundation had to be repaired.

Technical study of the problem narrowed the practical corrective steps down to these three. (1) Grout under the tank for $30,000, (2) excavate and put in fill, $80,000, (3) relocate the tank, $160,000. Grouting under the tank is accomplished by cutting a hole in the steel tank bottom and forcing liquid mud or cement under pressure underneath the bottom until it is raised up to the original elevation. If the surrounding soil is sufficiently strong, this is an effective repair method. In order to excavate and put in new fill, the tank would have to be moved, the weak area of soil excavated, the hole filled and fill compacted and the tank replaced.

Although relocating the tank was relatively easy, because space was available near at hand, the cost would be high primarily because of the necessity for changing piping which was already installed.

Because no one had expected the settlement to take place, sufficiently detailed measurements were not made before the water test so that definite conclusions could be reached as to exactly what happened. Soil tests and other studies made after the failure were not decisive. Among the possible causes of failure were: (1) a poorly compacted volume of soil of relatively limited extent which could be corrected by the grouting operation described above. (2) A shear failure of the soil under the tank. If soil is loaded too much it fails in shear, that is, a roughly conical-shaped plug of earth is pushed down and in turn slightly raises the level of the surrounding ground. Extremely accurate measurements are required to determine whether this has happened and unfortunately "before" measurements had not been made. It was known from the gross weight of the tank and contents that replacement soil could be provided which could stand the load. (3) The possibility that the settled portion of the foundation was actually the beginning of a small landslide. Taking even the worse of these possible explanations, i.e., the landslide, it was certain that relocating the tank at a cost of $160,000 would definitely solve the problem because test borings made after the failure showed the new site to be completely on solid rock whereas the present position was not. Although the most expensive course was certain to solve the problem, either of the two less costly methods might also be successful.

There was also the possibility that if the cheapest course were tried and failed, enough might be learned from the manner of failure to indicate a next step different from those initially considered. This second step, of course, might cost more or less than the $80,000 estimated for the excavate and fill step.

Note that the problem is completely surrounded by uncertainty and that there is a possibility of taking a "calculated risk."

Taking a "calculated risk" is a way of saying that probabilities are being analyzed and compared. Probabilities are analyzed for economic problems in the following way. Consider only for a moment the $160,000 "relocate" and the $80,000 "excavate and fill" alternatives. A definitely satisfactory result could be obtained at a cost of $160,000. If the $80,000 excavate and fill alternative were tried first and failed, the satisfactory correction would then cost that $80,000 plus $160,000

more to relocate the tank or a total of $240,000. Therefore, if the $80,000 first step alone were successful one-half the time, the average cost of all cases would be the same as using the $160,000 alternative. Stated differently, a 50–50 chance (50% probability) of success for the "excavate and fill" course is the break-even point. If the chances of the "excavate and fill" step succeeding were better than even, then that solution had the greatest probability of being the most economical selection. It must be remembered, however, that the theory of probability predicts what will happen in the "average" case and not in a single case.

At this point, the next step might appear to be that of estimating the respective probabilities of the different courses being successful and proceeding directly to selecting the most economical choice. You will find that most real problems are so complex that this does not work out for two reasons: first, even given the probabilities, it is impossible to visualize the interactions of the various factors without benefit of pencil and paper and algebra. Second, the probabilities associated with respective alternatives cannot be objectively established very well and the people making the decision must also weigh the probabilities which have been assumed when they are making the decision. Having these principles in mind, we can proceed with the analysis.

Analysis

The first step in the analysis is to list all possible courses of action. Each course must include not only an initial alternative which might succeed, but can proceed through various subsequent steps and end with an alternative which is virtually certain to succeed. In this problem, the only alternative certain of success was to relocate the tank. (If one of the intermediate steps has some likelihood of damaging the tank, this is reflected in a greater than $160,000 cost for the final relocating step.)

Following out the rule just stated and applying what has been stated about the

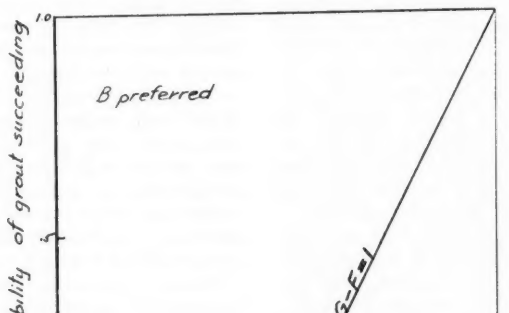

FIG. 1

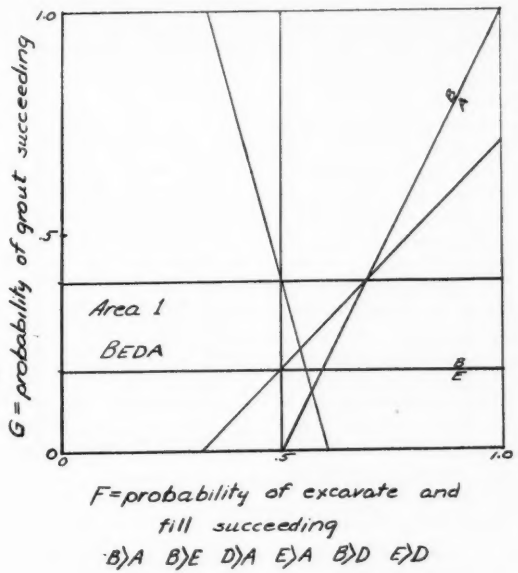

FIG. 2

problem of the storage tank foundation, it can be developed that there are a total of five alternate cases having 23 possible courses of action.

One case, for example, assumes (1) that no damage to the tank will be caused by the failure of any of the repairs, (2) that earlier steps do not influence the cost of subsequent steps and (3) that no useful information will be gained from watching the manner of failure of one of the earlier steps, should it fail. For this case, the possible courses of action are (A) grout and move, (B) grout, excavate and move, (C) excavate, grout and move, (D) excavate and move, (E) move. Note that in each case, any one of the alternatives could prove successful and, of course, work would be stopped as soon as a successful solution is found.

Equations for probable costs of the different possible course of action in terms of the respective probabilities of success for the individual steps are then set up. Specifically, if G equals the probability of the grout step being successful and F the probability of the excavate and fill being successful, the equation making the probable cost of course of action A equal to that of B is $30G + 190(1 - G) = 30G + 110(F - G) + 270(1 - F)$. This equation reduces to $2G - F = 1$ and the graph of this equation is shown on Figure 1.

Combinations of probabilities lying on the line are on the break-even point. Combinations of probabilities giving points to the upper left section indicate the B course of action to be preferred, and in the lower right, the A to be preferred.

Probable costs of all courses of action are similarly equated and the solutions are shown in Figure 2.

Consider Area 1 for a moment. In Area 1, B is preferred with respect to A, and also B is preferred with respect to E. A similar study of the diagram with respect to each line on it gives preferences in the order shown below the chart for

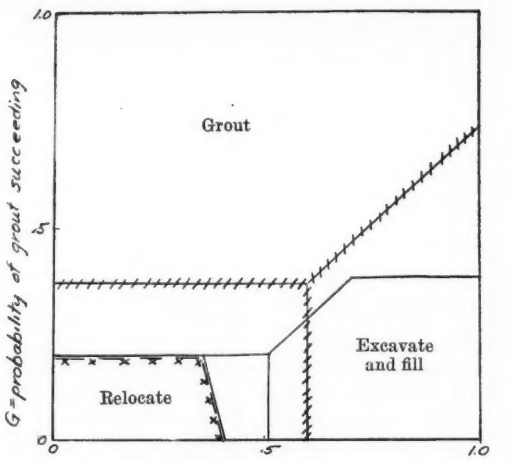

FIG. 3

Area 1. This preference order can be listed as shown in Area 1 on Figure 2. By similar reasoning the chart can be divided into three areas. These areas indicate courses having the odds in their favor for all possible combinations of probability of success for the alternatives.

Other cases to be considered include (1) when the failure of any course leads to high subsequent cost because of damage or (2) when failure of one of the courses leads to indications that cheaper, or more costly, alternatives should be taken rather than those originally contemplated.

The analysis of the five cases and twenty-three sub-cases is summarized in Figure 3.

On this composite chart, for example, the case which assumes the initial failure damages the tank and thereby makes subsequent steps more costly, requires a higher likelihood of success for the grout method than do the other assumptions. This is what would be expected. Similarly, the assumption that observing the method of failure of the grout case will suggest a second step less costly than the $80,000 excavate and fill step counsels for only two choices, i.e., grout or relocate. This is to be expected on the basis that if the $30,000 course is tried and fails, but the observation of the failure suggests a $20,000 second step, both of these steps could be obtained for $50,000 which would certainly be preferable to spending $80,000 initially.

Figure 3 summarizes the economic situation. When one locates his position on this graph, the preferred course of action is clear.

Unfortunately, dependable estimates of these probabilities were not available. It

is often erroneously assumed that when technical questions are involved, estimates of such probabilities are readily available. On the contrary, they are generally not available and were not in this case either. The problem was to make the best estimate taking all things into consideration. A chart similar to Figure 3 was used in this estimating process.

The line of reasoning was somewhat as follows: (1) If grout will succeed, it is probably true that only a relatively small volume of soil is weak and it can be strengthened by the grouting procedure and the load will be effectively carried by the surrounding soil. If this is true, then excavate and fill will succeed as well. This suggests that the area of Figure 3 to the lower right of a 45° diagonal line passing through the origin contains all reasonable situations.

For a 50–50 chance of grout being successful, the choice is clear for every case except the one which assumes damage to the tank. Technical considerations of the possible manner of failure of grout, however, strongly indicate that damage to the tank is not likely to occur.

Note also that if no damage occurs, for a 50–50 chance for grout, the decision does not depend on whether the proper value is 45–55 or 55–45—the split need only be better than 1 in 5 in the left portion of the chart. High probabilities of success for excavate and fill technically implies good probability for grout succeeding since high probability for excavate and fill would be the consequence of a strong surrounding soil which is not likely to fail, i.e., it is probably not the beginning of a small landslide. This situation would naturally be favorable for a grouting operation.

If faith in excavate and fill is rather low, it must be on the technical basis that extensive soil volume is of questionable strength. In this event, the chances in favor of grout must be reduced accordingly. This throws the case into the area favoring relocating the tank.

As can be seen, the use of this type of analysis does not eliminate the need for judgment. Reasoning such as above helps to clarify one's understanding of the technical situation and specifically indicates the economic inter-relationships. It does not indicate the values of probabilities that should be used. The best available technical judgment on these points is still an indispensable ingredient.

What this method does is to calculate those things which can be calculated and directs judgment at the critical point. For example, in this case, the initial technical judgment by competent engineers, and before seeing this kind of analysis, considered the probabilities in favor of grout being successful to range from 50% to 90%, i.e., some engineers stated 50, some engineers stated 90. This seems like a large area of disagreement and the various values were strongly supported by thoroughly competent technical experts. The interesting thing was that even granting any one of these values to be correct, the preferred course of action was by no means clear.

When, as a result of this type of analysis, the economic inter-relationships were developed and it was seen that the critical point for grout being successful was of the order of 20%, the problem assumed a different complexion. Whereas the engineers were not sure exactly what grout's probability was, they were very confident and in agreement that it was definitely better than 20% and very likely higher than 50%. On this basis, the preferred course was quite clear and used. Incidentally, it proved to be successful.

Other Problems

The same general kind of analysis has been applied to other problems. For example, in another instance we were faced with the problem of selecting between two designs of equipment. In a large plant, a change in process required the modification of two existing plant units. The original plant consisted essentially of two half-plants in which the units in question performed identical functions.

In the modified plant, the two units would also carry out substantially the same step. The problem concerned whether the same design should be used in both units or whether a different design should be put in each.

The costs of the two types of units were practically identical and were less than the fixed cost of one month of plant operation. The time required to obtain one of the units was about eight months. The two available designs were quite certain of working satisfactorily to some yield level. It was not known precisely what yield level could be expected from each, particularly which of the two was better, and a difference in yield of 5% was financially sufficient to warrant replacing the poorer one.

The problem was—what to do.

The initial risk analysis along the lines described in this paper finally boiled the problem down to understandable proportions. If the same design were installed in both units, it was equivalent to a bet of 3 to 2 that we were able to select the better design; the use of different designs in both was taking the opposite side of the bet, i.e., betting 3 to 2 that we could not select the better design.

In the light of all pertinent factors, it was decided that the better design could be selected. Orders were accordingly placed for two identical units and the matter considered closed.

Concurrently, laboratory and pilot plant work was proceeding and recently information was developed indicating that a design other than the one selected would prove to be better. Engineering studies developed that the design initially selected could be readily modified to the type indicated by the laboratory work. The fabrication schedule was such that one or both of the units ordered previously could be modified with slight delay to the project.

At this point, it should be stressed that both the lab data leading to the original selection and the new data leading to the different conclusion were not as clear cut as this paper may suggest. Time did not permit the exploration of all the quite obvious technical questions. Nevertheless, new data were available leading to different conclusions and time was available to make a change. The question again was—what should be done.

The data suggested that two of the modified design units should be installed. There was no certainty, however, that the latest data would not in turn be revised in the future. At the same time some factors also still indicated the original design to be good.

Again risk analysis, which took into account the new economic situation existing by virtue of commitments on the initial two units, as well as all other items involved in the plant, reduced the problem to understandable terms. To install two modified units would take considerable risk that the latest data were not correct. Specifically chances of 1 or more in 3 that the latest laboratory data indicated the incorrect *direction* of superiority counsel for installing one of each rather than two of the modified design. Note that this is different from the usual requirement that lab data show the relative merit quantitatively. The relationship of pertinent costs in this case was such that the key question was:—which is better. How much better was immaterial to the decision.

This problem, it might be mentioned, is current—so much so that the decision has not yet been made. Of interest here, however, is the fact that the initial discussions about the problem were along the conventional confusing lines characterized by vague discussions of uncertainty. The application of the risk analysis technique introduced a quantitative way of considering uncertainty in terms which were considerably more familiar to all concerned. Whatever the ultimate decision, it will have been made in a clearer understanding of the risks and their effects.

Summary

In summary, we believe that this is a useful technique for considering uncertainty in typical engineering economy problems. We have used it in connection with six widely different problems. In each it has been of use in translating the uncertainty in the situation into understandable terms frequently with some comparison to familiar experience. Risk analysis requires engineering competence, understanding of sound economic principles and ability to synthesize these elements into a composite story suitable to the problem at hand. We believe this type of analysis will prove of increasing value in industrial applications and has a place in the teaching of enginering economy.

ANNUAL MEETING

June 25-29, 1956

Iowa State College

Ames, Iowa

Report of the Secretary 1954–55

This report covers a period during which two secretaries functioned and has been prepared independently by the new secretary. It is thus possible that some items of significance may have been overlooked or inadequately treated. For such omissions apologies are extended.

Change in Secretary

The most significant event of the year was the resignation of Secretary A. B. Bronwell to accept the presidency of Worcester Polytechnic Institute. After the naming of the new Secretary the national office was moved to the University of Illinois, Urbana, Illinois. The office is conveniently located on the first floor of a former residence owned by the University and immediately adjacent to the campus.

The University is providing the space rent free, furnished funds for adapting the residence to office use, and provides the long-term maintenance necessary to keep the building in good condition. In addition, because the editorial secretary needs to divide time between the ASEE Office and the editor's office, the University is furnishing the needed space and equipment in the editor's office.

The Society is responsible for the cost of utilities and day to day janitorial services. By action of the Executive Board the Society purchased sufficient furniture to equip all the offices. Since the Society already owned all the mechanical equipment, the Society now is essentially independent of the host institution in so far as furniture and equipment are concerned.

The editing of the JOURNAL OF ENGINEERING EDUCATION was to be transferred from Professor C. E. Watson of Northwestern University to Professor L. A. Rose of the University of Illinois, on July 1, 1955. The sudden and untimely death of Professor Rose delays the date of such a change and Professor Watson has agreed to function as Editor until other arrangements materialize.

Unfortunately, no one in the Evanston office was able to move to Urbana. Consequently the office staff is entirely new and consists of

Executive Office Secretary
Mrs. Naomi Garman
Membership Secretary
Mrs. Louise Chambliss
Editorial Secretary
Mrs. Sandra Sokolow
Typist
Mrs. Elsie O'Brien

Each of the new staff, except the typist, was able to spend from two days to almost two weeks in Evanston in order to be briefed in their respective duties.

In establishing the office in Urbana the first objective was to systematize the routine matters of operation; secondly came the Annual Meeting. Almost all other matters were placed on a lower level of importance and thus relations with the General Council, Division Officers, and Committee Chairmen most probably have not been as close as they should have been. Some desirable activities and procedures were not carried out, such as the President's Newsletter, providing information to members of the General Council in advance of the meeting, and providing a semblance of helpfulness and willingness for cooperation to committee and division officers.

Projects

1. *Evaluation of Engineering Education.* The Interim Report presented last year has been revised to reflect the comments of the institutional committees which studied it in detail. The final report of the committee will be presented at this year's Annual Meeting and copies will be available to those attending the meeting. The completion of this project was made possible by additional grants of considerable magnitude by the General Electric Company and the United Engineering Trustees, Inc. The society greatly appreciates their continued support.

2. *Humanistic-Social Research Project.* A preliminary report is to be presented at the Annual Meeting and the final report will be completed and published in the Fall. This report on what actually is being done at some institutions should be a valuable supplement to the report on Evaluation of Engineering Education.

3. *Educational Aids.* The booklet has been printed and is available from the Secretary's Office for $1.00 per copy. About 500 of the 2000 copies printed have been sold.

4. *ASEE–NSF Conferences.* As a result of the two successful Summer Institutes of last year, three ASEE–NSF jointly sponsored conferences were held. Each of these two-day closed conferences of about twenty-five leaders in various fields of engineering, as well as from mathematics and physics, was financed by the National Science Foundation. The program and personnel invited also were developed with their close cooperation. The report on each of these conferences is in the May issue of the Journal of Engineering Education. The findings of each of these conferences are the bases for open discussion meetings at the Annual Meeting, or, in the case of thermodynamics, the conference following the Annual Meeting. The conferences were all held in February and are as follows:

Mechanics—Physics
New York University
Electricity and Magnetism
Lehigh University
Thermodynamics
Purdue University

The Society is deeply indebted to the National Science Foundation for its great interest and cooperation in organizing and sponsoring these conferences as well as for its financial support.

5. *Graduate Study Project.* The ad hoc committee on the preparation of the Graduate Study Project has proceeded with its plans for an extensive study of graduate work. The program submitted centers on "Current Problems of Graduate Education in Engineering." Five problems have been agreed upon and briefly may be stated as being:

(1) Since high level industrial employment profoundly affects the caliber of students entering graduate schools, is a cooperative program between universities and industries indicated to assure the nation an adequate supply of graduate engineers?
(2) The effect of sponsored research and research fellowships on the development of student initiative and leadership.
(3) Part-time programs at the graduate level, flexibility and standards.
(4) When and under what conditions can an institution effectively undertake graduate work?
(5) The scope and breadth of graduate work, particularly for men already employed in industry.

A budget is now being submitted to the Executive Board along with proposals for financing.

6. *Theoretical Engineering.* The ad hoc planning committee under the chairmanship of Dean F. C. Lindvall has proceeded in accordance with its instructions of last year. A conference with representatives of the National Science Founda-

tion will be held at the Annual Meeting. It is contemplated that the closed conference be at the California Institute of Technology and the open conference at the University of Michigan.

7. *Summer Schools.* The Society is sponsoring two Summer Schools and one Conference this year. All are being held at The Pennsylvania State University and are as follows:

English Division—"Communication: experiment and experience"

Chemical Engineering Division—"What's ahead in chemical engineering education?"

Thermodynamics Conference—"Developments in thermodynamics having an impact on engineering, technology, science and teaching."

The Society cooperated with these projects by publishing a brochure and mailing it to some five hundred deans, directors, etc. and in other miscellaneous ways.

8. *YET Activities.* Interest in the YET program has continued, even though no specific charge such as conducting a membership campaign was assigned them. Thirteen of the sixteen sections submitted papers in the contest. This year, the winning papers will be read at the Annual Meeting and all thirteen papers are being submitted for possible publication in the JOURNAL OF ENGINEERING EDUCATION.

Membership

The individual membership in the Society has continued to increase. The number listed in the 1955 Yearbook is 7560 whereas it was 7095 in 1954 and 6875 in 1953. At this year's Annual Meeting, 15 members are being recommended for life membership; 250 have resigned, 42 have died, 99 are more than two years delinquent in dues, and 917 have not paid their dues for the year despite receiving three dues notices. The last figure seems to be much greater than in past years and must be reflected in next year's budget.

After the concentrated effort of the past two years it was thought desirable not to push Institutional membership; instead it seemed advisable to observe the stability of the recent growth. The 1955 *Yearbook* lists 112 such members, whereas 96 were listed in 1954 and 35 in 1953. During the year two dropped their membership and ten have not paid this year's dues. The active support of this type of membership is desirable and the committee will renew its promotional activities next year.

The number of Active and Affiliate Institutional Memberships also has increased slightly. The yearbook figures for the former are 29 for 1955, 28 for 1954, and 27 for 1953. The Affiliate totals are 29 for 1955, 28 for 1954, and 27 for 1953.

Relation with Industry Division Meetings

The Relation with Industry Division and the Iowa Engineering Society held a "College Industry Conference" at Des Moines, Iowa in March. About four hundred attended the various sessions devoted to a discussion of current problems facing the engineering profession, especially as they affect the young engineer and his development and progress in industry.

This important division, linking ASEE closely to industry, has as the theme for its Annual Meeting program "How Do We Compare Scientifically with the People Behind the Iron Curtain?" The presentation will cover the legislative matters affecting the training and utilization of scientific and engineering manpower in this country and in Russia, and the quality and quantity of the scientific and engineering education in the two countries.

Division Publications

Last year's report of the Secretary listed the publications of the Divisions, recognized their value, and gave credit to their editors. The publication of such periodicals is becoming increasingly difficult, at least in two instances, because of the withdrawal of the support which enables them to be provided to all members of the Division at no cost. Present publications and the editors are:

Civil Engineering Bulletin
A. A. Brielmaier, Washington University
Chemical Engineering Transactions
A. H. Cooper, University of Maryland
Heat Power News and Views
J. S. Doolittle, North Carolina State College
Journal of Engineering Drawing
W. J. Luzadder, Purdue University
Machine Design and Manufacturing Process Bulletin
E. E. Day, University of Washington
Mechanics Bulletin
A. W. Davis, Iowa State College

Cooperation with Other Organizations

During the year the ASEE continued its active participation in the affairs of the Engineers' Joint Council, Engineers' Council for Professional Development, etc. Dean Thorndike Saville again served as President of EJC. The Society is cooperating with Lehigh University, the American Institute of Steel Construction, and the American Society of Civil Engineers in sponsoring a summer course, "Plastic Design in Structural Steel," to be held at Lehigh University, September 7–15, 1955. The Society provides no financial support.

By virtue of its membership in Engineers Joint Council the Society is instrumental in EJC's planning of the Nuclear Engineering and Science Congress to be held at Cleveland, Ohio, December 11–17, 1955. Twenty-four organizations with a total membership of 250,000 will participate and almost 200 papers have been submitted for presentation. The purpose of the Congress is to discuss the pressing problems of nuclear engineering and the related sciences, with emphasis on the industrial usefulness of atomic power.

ECAC and ECRC

The activities of these organizations are reported separately in this issue of the Journal.

It is only appropriate to acknowledge, in closing, the whole-hearted and unselfish cooperation given the new Secretary and the new office staff by former Secretary A. B. Bronwell, former Executive Office Secretary Miss Marion Strohm, and Assistant Secretary C. E. Watson. We are all grateful for their aid in helping us overcome some trying situations. The patience and courtesy of President N. W. Dougherty is also greatly appreciated.

Respectfully submitted,
W. Leighton Collins, *Secretary*

Report of the Vice President, Leo J. Lassalle, in Charge of Instructional Committees and Divisions For the Year 1954–55

On June 15, 1954, at the Annual Meeting of the ASEE in Urbana, Illinois, I was elected Vice President of the ASEE in charge of committees to succeed Vice President W. C. White. Vice President White was very helpful to me in outlining the duties and responsibilities of my new position, and I wish to thank him for this valuable and willing assistance.

On July 12, 1954, the new President of the ASEE, Dean N. W. Dougherty, of the University of Tennessee, called the then Secretary, Prof. A. B. Bronwell of Northwestern University, and me to a meeting at his office in Knoxville, Tennessee, for the purpose mainly of considering the selection of chairmen and members of the various committees of the ASEE.

We met all day and agreed upon the main appointments. Necessarily, certain details had to be left to the Secretary and President for further correspondence, discussion and decision. However, as the result of the meeting, the present commitees were named and have been functioning efficiently, as indicated by the work they have done in planning the Annual Meeting at The Pennsylvania State University.

The Executive Board of the ASEE met in New York City and transacted the business of the agenda. See agenda and minutes of this meeting for details of this meeting which was held September 11, 1954.

On October 27–29, 1954, The Executive Board as well as the ASEE Committee on the Annual Meeting met in Cincinnati. These meetings coincided with the ECPD at the same time and place. The business transacted is detailed by the agenda and the minutes of the meeting at the Hotel Alms, Cincinnati, on October 27–29.

Prior to the above meeting, and after it, the Executive Board was confronted with the impending resignation of the very able, experienced and efficient Secretary of the ASEE. The fact that he was resigning to accept the presidency of the Worcester Polytechnic Institute made us proud of him, but it did not lessen the gravity of the problem of selecting his successor and the dislocation caused by the change.

President Dougherty took all necessary steps, with the aid of the Executive Board, to set in motion the necessary machinery for the selection of a new Secretary. Among other actions, he addressed a letter to the deans of the various engineering schools that are institutional members of the ASEE and to others, asking for their suggestions and assistance in the selection of a new Secretary. By this method, and after additional meetings of the Executive Board and committee appointed by them, we were very fortunate in securing the services of Prof. W. Leighton Collins, of the College of Engineering, University of Illinois, as Secretary.

Our thanks are certainly due to Dean W. L. Everitt for his assistance in working out the many details of this appointment, as well as to Professor Collins for accepting this difficult assignment.

On November 16–18, 1954, the Executive Board met in Washington, D. C. on the occasion of the Annual Meeting of the Association of Land Grant Colleges and Universities there.

We again considered many matters as indicated by the agenda and the minutes

of this meeting. This was the last time we were to meet with our past Secretary, Prof. A. B. Bronwell, in charge of details and arrangements. He assumed the presidency of Worcester Polytechnic Institute on Feburary 1, 1955 and Professor Collins assumed the secretaryship then.

On March 26, 1955, I attended the Annual Meeting of the Missouri-Arkansas Section of the ASEE as representative of the Executive Board and I was the main speaker at their banquet. I brought the greetings of the Executive Board and spoke on "The American Society for Engineering Education and its Work in the Years Ahead."

On April 15, 1955, the Executive Board met in Knoxville, Tennessee in President Dougherty's office on the occasion of the Annual Meeting of the Southeastern Section of the ASEE at the University of Tennessee. This was our first Executive Board meeting with Professor Collins as Secretary of the ASEE; and he demonstrated that he had been well-tutored by the outgoing secretary and that he was an apt pupil, by presenting the Executive Board with the usual well-prepared agenda and by assisting us in transacting the business presented to us.

At this meeting, among many other actions as shown by the agenda and the minutes of the meeting, we elected Prof. Lisle A. Rose as Editor of the Journal of Engineering Education and Public Relations Director of the ASEE to succeed Prof. C. E. Watson, who necessarily had to resign this position, due to the fact that the Editor and Secretary cannot function properly in their related duties unless their offices are located close to each other.

Prof. Lisle A. Rose was to assume office on July 1, 1955. We, as well as his many other friends, were shocked and grieved by the sad news of his sudden death before he was able to assume his new position. The ASEE has suffered a great loss as Professor Rose was an able and indefatigable worker, who possessed the rare combination of ability and enthusiasm that would have made him a great editor of the JOURNAL OF ENGINEERING EDUCATION, but for his sudden death. I can only join, in an inadequate manner, in expressing to his family and friends my sincere sympathy.

The work of the many committees and of the outgoing and incoming secretaries and their staffs can best be shown by the reports of the activities and by the meetings planned and held here at The Pennsylvania State University in connection with the 63rd Annual Meeting of the American Society for Engineering Education.

Annual Report of Vice President, B. R. Teare Jr., in Charge of Sections and Branches June 17, 1955

The Sections and Branches of the American Society for Engineering Education have had another healthy, vigorous year. Their programs have been stimulating and well attended as I know from first-hand observation at the meetings in which I have participated.

As I reported last year, I have been giving much thought as to how the various subdivisions, Sections, Branches, Divisions, Committees, and so forth, of the Society best can be integrated with each other, and how the totality of subdivisions best can serve the individual membership of the Society. We may think here of two kinds of service: one, originating, developing, and formulating ideas that will advance engineering education; and

the other, communicating them with penetrating discussion and criticism throughout the Society. The development of ideas can and should occur in every subdivision of the Society; indeed, Divisions and Committees are organized expressly for this purpose, and the various topics of interest to the Society are apportioned among them. On the other hand, Sections and Branches are free to consider ideas of any kind, ideas that may also lie within the province of any one or of several of the Divisions and Committees.

Sections play a very important role in the Society structure by providing excellent opportunities for the communication and discussion of ideas, supplementing the national meeting. This needs reinforcement because it is limited in duration and because sessions compete with one another. A Division or Committee program often cannot reach all members of the Society that are interested; some are not able to come to the annual meeting, and those who do cannot be in two sessions at once. Sections, however, provide excellent alternative channels of communication. Their programs can be organized around fewer topics which lessens conflicts. Also, in most instances, the Section is small enough so that travel to its meetings is not as difficult as to the national meeting, and yet the Section contains enough different institutions, 5 to 22, to provide a stimulating diversity of point of view.

Thus, if the communication of ideas within the Society is to be improved, and many members feel that this would be desirable, one method of doing so is by working through the Sections. It may be that ways can be found to increase the already good attendance at Section meetings, and reach more members who do not attend the national convention. Also, I think that the Section programs to a greater extent than now can be directed toward the dissemination and discussion of matters that are of current interest to the Society as a whole. In my contacts with Sections I have been urging an increased cooperation between Sections and Divisions to this end. More often than is done now a Section might choose one or two Divisions to help plan and put on its meeting. The Divisions called upon would probably be one like Educational Methods, Graduate Study, Relations with Industry, or others; that is, of the kind that are the concern of more than one major branch of engineering. Alternatively, a Section might call upon a Committee that is working on a major Society project. The Division or Committee would assist the Section in planning the program, but the actual participants might well be members of both groups.

Such cooperation is to the advantage of both the Section and the Division. The Section gets help with its programs, and these are kept within the main channels of Society thinking. The Division has the opportunity of reaching more members, and this means more discussion and criticism to aid in the development of ideas.

A few Sections are so large, with distances between institutions so great, that attendance at meetings seems quite expensive. It has been suggested that consideration should be given to boundary changes that would reduce distances to be traveled. However, in several discussions I have held with the officers of large Sections it has seemed clear that in spite of present disadvantages there is little sentiment in favor of a change. To force a change is unthinkable; our tradition is to give the Sections fullest autonomy in all their affairs.

In the last few years many industrial organizations have joined the Society as associate members, in part as the result of a successful membership campaign. Such members may be distinct assets to Sections and Branches, but only if they are included in Section and Branch activities. This would be desirable from both the local and the national points of view.

During the year, in the course of revising the constitution of the Upper New York Section, it was pointed out that Article IX, Section 3, of the National Constitution may need revision. Here the Constitution states that

"Section 3. Papers and discussions presented before Sections or Branches shall be the property of the Society and may be published as Society proceedings if authorized by the Publication Committee. Permission to publish such papers and discussions elsewhere may be granted by the Executive Board of the General Council on condition that the Society receives proper credit."

This mandate may not be completely enforceable because in some cases a Section or Branch may invite a distinguished man to appear on a program and may not feel that it is in a position to claim his paper as Section or Branch property. The matter has been referred through the Executive Board to the Committee on Constitution and By-Laws.

It has been a great pleasure to be associated with the able officers and members of Sections, and I gratefully acknowledge their help in carrying out my duties, also the splendid cooperation of our national headquarters.

Annual Report of the Chairman, Harold K. Work, of the Engineering College Research Council June, 1955

During the past year, the Engineering College Research Council has continued to work on the various problems facing engineering schools, doing sponsored research. The basic problem has been approached in various ways, which are detailed as follows:

Publications

A new edition of "Review of Current Research and Directory of Member Institutions" has been prepared and will be available early in July. This booklet should be valuable to all of our member institutions, to individual faculty members, and to sponsors who are trying to locate and evaluate institutions for handling their research. The Secretary of the ECRC, Mr. Renato Contini, has been responsible for this publication.

A committee under Eric A. Walker has been working on the preparation of a book on "Creativity in Research." They are using as source material a group of papers presented at various symposia and meetings sponsored by the ECRC. In addition, some special solicited papers may be included. The available material is now being evaluated by a publishing house.

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has prepared a brochure entitled "Sponsored Research Administration." This is an excellent handbook, covering many problems of interest to the research administrator. It will be published and distributed to member institutions. Provision may also be made to make it available to others.

Relations with Federal Government Agencies

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has continued to be one of our most important and active committees. The Committee has considered a variety of subjects and a brief resumé of such activities will be given here.

Overhead and direct cost of research conducted for the Government are being

studied by the committee. A problem exists with the Department of Health, Education and Welfare and others, who do not want to cover the full cost of the research. The Committee will continue to press for a single standard of payment for research in which research costs are fully reimbursed above the lines of the Mills formula.

A regulation promulgated and distributed by the Department of Commerce which imposed severe limitations on engineering schools in the performance of their functions in education and research was the subject of considerable concern. Through the activities of the committee the regulations were redefined in such a way that it minimized the objectionable features as far as educational institutions were concerned.

Relations with Industrial Research Agencies

The Committee on Relations with Industrial Research Agencies under S. T. Carpenter continued to maintain relationships with those organizations most concerned with industrial research. These included the Research Committee of National Association of Manufacturers and the Industrial Research Institute. An attempt was made to arrange a regional conference with NAM but this did not materialize.

As a part of the annual program the committee arranged joint sessions with the Graduate Studies Division on subjects of interest to industrial research people as well as engineering research people.

Awards

At each ASEE Annual Meeting a series of awards is given for various educational activities but there is no award specifically aimed at the stimulation and improvement of engineering research. A Committee was set up under the chairmanship of R. J. Martin to determine whether or not such an award was desirable. This was decided in the affirmative and the committee is now trying to define the nature of the award and arrange for its financing. It is the intention to announce at the 1955 annual meeting that such an award will be initiated in 1956.

Basic Research

The Committee on Basic Research which was originally set up to help the National Science Foundation in its engineering research activities, has been dropped as its services are no longer needed.

Research Administration

Many of the problems in the administration of sponsored research are not covered by our present committees. For example, the excellent salary analysis recently prepared by Virgil E. Neilly would fall in this category. It was decided, therefore, that a committee was needed on research administration which might study various problems in research, such as (1) overhead costs, (2) security requirements and (3) extra salary payments for staff members engaged in classified research, etc. R. A. Morgen was appointed chairman of the Committee and selected as his first project, the study of how research personnel, in various research organizations, are handled in the matter of tenure, fringe benefits and so forth. The Committee is also considering a study of standardization of reports.

Program for the National Meeting

The program committee under the chairmanship of R. G. Folsom has developed an interesting program. In order to be certain that people interested in both education and research would find something of interest in the program, the general session involves relationships between the two. Three eminent speakers, two of which are engineering school presidents and the third a corporation president, have been secured.

Another joint dinner has been arranged with the ECAC and Dr. E. W. Engstrom

Vice President of the Radio Corporation of America, will be the speaker.

Two joint, open sessions have been arranged with the Graduate Studies Division. It is felt that the combination of our activities with those of other committees should be encouraged in the interest of converting small competing meetings into better joint meetings.

As is customary, a closed session will be held at which the various problems of ECRC members will be discussed on a more or less confidential basis.

Four executive committee meetings were held during the course of the year as well as numerous committee meetings.

Nominations

The Nominating Committee under the Chairmanship of Frank W. Dawson presented names to replace the following officers who are retiring:

R. A. Morgen
F. C. Lindvall
G. R. Town

Those nominated by the committee and elected by the ECRC representatives are as follows:

K. F. Wendt
T. J. Killian
H. W. Barlow

Annual Report of the Chairman, William L. Everitt, of the Engineering College Administrative Council July 1, 1954—July 1, 1955

Executive Committee Meetings

This year the Executive Committee held one meeting which was on November 17, 1954, during the Land Grant College meetings at Washington, D. C. At this, the 1955 Annual Meeting program was outlined and matters were subsequently handled by correspondence. Minutes of this meeting were circulated as Appendix I of Executive Committee Bulletin Number XVII of May, 1955.

A luncheon meeting of old and new members was held on June 23 at Pennsylvania State University to discuss plans for 1955–56.

Nominating Committee

At the November Executive Committee meeting, the following nominating committee was appointed by Chairman Everitt: W. G. Van Note, chairman; R. A. Morgen; E. W. Schilling and C. L. Wilson. Balloting on the slate proposed by the nominating committee resulted in the following elections for a term of two years:

Chairman, W. T. Alexander
Secretary, R. A. Morgen
Executive Committeemen, H. E. Wessman and J. R. Cudworth

Military Affairs Committee

In June this committee was requested by the ASEE Committee on Evaluation to make a survey of the ROTC situation, particularly with regard to net graduation credits earned through ROTC.

All deans of engineering were canvassed in September to determine (1) credit being granted for ROTC courses, (2) educational value of advanced courses in opinion of engineering educators, (3) experience with "General Military Science" where conversion from "Branch Material" programs had occurred. A complete report of this study will be published in the JOURNAL. This study indi-

cates that an average of 14.3 credit hours is allowed toward the B.S. degree. Figures published by the Army in February, 1955 show slightly higher figures of 15.9 credit hours.

In March, 1955, the chairman requested a statement of Army policy toward conversion of ROTC units from Branch Material to Branch General from General P. F. Linderman, Chief, Army Reserve and ROTC Affairs. General Linderman replied, "The choice between the two programs continues to be voluntary on the part of the institutions concerned."

Selection and Guidance Committee

The two major projects of this committee for the year were:

1. To maintain contact with the research being carried on by the Educational Testing Service to develop a placement test for engineering graduates.
2. To develop a list of books germane to engineering and suitable for the guidance of high school students.

Placement Test Research. This project has continued from a start last year under the sponsorship and with the cooperation of five companies: The Bell Systems, Detroit Edison, B. F. Goodrich, IBM and Westinghouse. The hope that other companies would participate has not yet materialized. A more detailed progress report on this research was made at the June 20 ASEE General Session.

After study, the initial division of young engineers four to seven years after graduation into Research, Design, Manufacturing, Sales and Supervision was abandoned in favor of the following functional groups:

Technical Engineering

1. Research Engineering
2. Applications Engineering
3. Design Engineering
4. Product Engineering

Administrative Engineering

5. Operations Engineering
6. Supervisory Engineering
7. Sales Engineering

"The labels here attached to the seven groups do not necessarily conform to normal engineering usage. . . . The groups are defined by the ranking-in-importance of the unit activities, and these ranks also define the labels as far as the present context is concerned. Any reader who disagrees with one or more labels is free to substitute on his own, without otherwise affecting the results or discussion," said Dr. D. R. Saunders.

Preliminary work indicated two main conclusions:

1. "The difference among engineering jobs, for engineers having five to seven years of post graduation experience, are much greater within companies than between companies."

2. "The differences as observed in one company tend to parallel the differences as observed in another company, although not all functional groups are represented in every company."

Early in 1955, after preparation and evaluation of the test battery the tests were administered to 1929 young engineers at 50 locations in the U. S. and Canada. From the 1929 engineers tested, 800 were included in a sample for analysis and a total of 56 scores were obtained from each.

In view of the relatively high levels of confidence and statistical significance observed in the scores, a cross validation with an additional sample is not highly important.

Preliminary inspections suggest that the tests can differentiate functions generally, predict success ratings generally, or predict membership or success in particular functions.

Further work is progressing to produce the last battery that can be made available for testing newly hired engineers.

A book list, prepared previously, was discussed on a June 21 committee meeting.

Secondary Schools Committee

This committee has continued its efforts further to improve the study of college-high school cooperation. Particular attention has been directed to the following:

Guidance. There is continuing need to direct more and better prepared students into the colleges of engineering. Engineering schools should continue and expand their guidance work through direct association with secondary schools, through alumni groups, and in cooperation with technical societies.

In the opinion of this group, ASEE should take an active part in preparing a guidance book which would tell more of the actualities of an engineering education in college. This would supplement the existing pamphlets, and be written in general terms for distribution through engineering schools. Individual schools could supplement the basic guide with specific information about their schools. This committee recommends that ASEE consider supporting a project to prepare such a guidance booklet.

Future Engineer's of American Clubs. These clubs exist in some high schools and have much merit. It is recommended that the formation of these clubs in high schools be promoted by engineering schools in cooperation with the technical societies.

High School-College Articulation in Mathematics and Science. Considerable study indicates that the extreme difficulty involved precludes establishment of a nationwide program. It must be developed by the schools in each state. This program is well developed in Illinois and the information is available to other states.

Cooperation with Secondary Schools. Only harm can result from a critical and superior attitude toward the secondary schools. A program of friendly cooperation and helpfulness is the only hope of elevating the secondary school standards, with a resulting elevation of the level of instruction in the engineering schools.

Industrial Scholarship Committee (ad hoc)

At the 1954 meeting for Institutional Representatives, the following vote was passed: "The Chairman appoint an *ad hoc* committee to investigate the propriety and necessary mechanism for ASEE to act as a clearing house for industrial scholarship funds."

In compliance with this vote, Dr. R. A. Morgen was appointed chairman and preliminary investigations are in progress. This committee made a detailed report at the Annual Meeting.

Manpower Committee

A definite report is difficult as major legislation affecting manpower was held up in the House of Representatives. Widespread sentiment for more *selective* processes in induction and utilization by armed forces waits for final word from the Congress.

The Selective Service situation appears to be unchanged, including a tightening of graduate deferment requirements. The ROTC situation is unclear, but the program seems stabilized numerically, and may have more technical flavor.

In currently proposed legislation, it is provided that men educated in critical disciplines will be able to enter their specialty after six months of military training and service as compared to the present 24 months requirement.

Increasingly widespread awareness of the importance of technology and recent information concerning education in Russia should result in better utilization of specialized talents for the common good.

ASEE should continue full support and assistance to the Engineering Manpower Commission. A recognized spokesman for engineering is and has been of signal importance.

Foreign Operations Administration Committee

This committee was formed to advise and assist the Foreign Operations Admin-

istration as needed, particularly in personnel matters.

Although the chairman has met with Dr. Andrews of FOA several times and certain committee members have served individually, FOA has increasingly contracted its technical, educational, and research problems with a broad group of universities. Consequently, the committee, as such, has not been asked for assistance during the year.

In view of this situation, it is recommended that this *ad hoc* committee be discontinued and its functions transferred to the International Relations Committee.

International Relations Committee

In general the work of this committee has been directed to contacting as many educators from other countries who might be in this country at the time of the Annual Meeting as is possible. Also to be sure that they will be warmly welcomed if they attend the ASEE meeting.

In many cases opportunities for building good will are lost through the lack of a special effort to be hospitable to educators from other lands. The impressions gained from personal relationships last for many years and can do much good or much harm.

News Bulletins

ECAC Executive Committee Bulletins were circulated to the membership and to the ASEE officers and council members twice during the year.

ASEE Meetings at Michigan State University

Executive Board, Sunday, November 13, dinner meeting at 6 p.m.

General Council, Monday, November 14, dinner meeting at 6 p.m.

ECAC Executive Committee, Tuesday, November 15, breakfast meeting at 7:30 a.m.

ECRC Executive Committee, Tuesday, November 15, luncheon meeting at noon.

Report of the Resolutions Committee June 23, 1955

The Committee on Resolutions recommends the adoption by the Society of the following statement:

The American Society for Engineering Education wishes to express its sincere thanks to the many people who have generously contributed so many thousands of man and woman-hours of intelligent planning and devoted work toward making this, our 63rd Annual Meeting, one of the most notably successful and enjoyable in our history.

Our thanks are extended to the national and divisional officers and committees, the General Council, the Administrative and Research Councils, and the many speakers, all of whom have taken time out of busy lives to freely and generously render invaluable services to the Society.

Especially, we wish to express our most sincere appreciation to the members of The Pennsylvania State University Branch of The American Society for Engineering Education, their wives and their children, who have been responsible for the local arrangements which have contributed immeasurably to the smooth operation of all segments of the program, and to our comfort and convenience.

The efficient and painless registration process, the more than adequate provisions for our housing and sustenance, the entertainment features provided for us, and for our wives and our children, and the eagerness with which our needs and desires have been met, all combine to create a warm spot in our hearts for Penn State.

We are grateful to the University for inviting us to participate in its One Hundredth Anniversary celebration. We congratulate the University on her achievements during her first hundred years, and predict that the next hundred years will be equally successful.

The American Society for Engineering Education hereby directs that this statement be spread upon the official minutes of the Society, and that copies be sent to

President Milton S. Eisenhower
The Pennsylvania State University Branch of The American Society for Engineering Education
Dean Eric A. Walker

Committee: Frank Groseclose, Georgia Institute of Technology
Frank Kerekes, Michigan School of Mining and Technology
Henry H. Armsby, (Chairman) U. S. Office of Education

Officers of Divisions, Sections and Committees 1955-56

DIVISIONS

AERONAUTICAL: J. W. Hoover, Chairman, University of Florida

AGRICULTURAL: F. A. Kummer, Chairman, Alabama Polytechnic Institute

ARCHITECTURAL: L. A. Richardson, Chairman, Pennsylvania State University

CHEMICAL: H. P. Simons, Chairman, West Virginia University

CIVIL ENGINEERING: R. L. Peurifoy, Chairman, A. & M. College of Texas

COOPERATIVE ENGINEERING EDUCATION: R. G. Owens, Chairman, Illinois Institute of Technology

EDUCATIONAL METHODS: F. K. Kraybill, Chairman, Duke University

ELECTRICAL: W. C. Johnson, Chairman, Princeton, N. J.

ENGINEERING DRAWING: W. E. Street, Chairman, Texas A. & M. College

ENGLISH: T. H. Farrell, Jr., Chairman, State University of Iowa

EVENING ENGINEERING EDUCATION: K. W. Riddle, Chairman, Drexel Institute of Technology

GRADUATE STUDIES: N. A. Hall, Chairman, University of Minnesota

HUMANISTIC-SOCIAL: W. K. Brown, Chairman, Rensselaer Polytechnic Institute

INDUSTRIAL ENGINEERING: J. R. Huffman, Chairman, University of California, Los Angeles

MATHEMATICS: H. Reingold, Chairman, Illinois Institute of Technology

MECHANICAL: B. T. McMinn, Chairman, University of Washington

MECHANICS: H. F. Marco, Chairman, Air Force Institute of Technology

MINERAL ENGINEERING: C. O. Frush, Chairman, Iowa State College

PHYSICS: D. Loughridge, Chairman, Northwestern University

RELATIONS WITH INDUSTRY: W. Burton, Chairman, Minnesota Mining and Manufacturing Co.

TECHNICAL INSTITUTE: K. Werwath, Chairman, Milwaukee School of Engineering

SECTIONS

ALLEGHENY: J. W. Graham, Jr., Chairman, Carnegie Institute of Technology

ILLINOIS-INDIANA: O. W. Witzell, Chairman, Purdue University

KANSAS-NEBRASKA: R. M. Kerchner, Chairman, Kansas State College

MICHIGAN: G. H. Howell, Chairman, Wayne University

MIDDLE ATLANTIC: C. C. Carr, Chairman, Pratt Institute

MISSOURI-ARKANSAS: J. B. Macelwane, Chairman, St. Louis University

NATIONAL CAPITAL AREA: D. C. Jackson, Jr., Chairman, Aberdeen Proving Ground

NEW ENGLAND: E. R. McKee, Chairman, University of Vermont

NORTH MIDWEST: L. L. Amidon, Chairman, South Dakota State College

OHIO: E. C. Clark, Chairman, Ohio State University

PACIFIC NORTHWEST: J. B. Morrison, Chairman, University of Washington

PACIFIC SOUTHWEST: R. G. Moses, Chairman, Pasadena City College

ROCKY MOUNTAIN: W. H. Parks, Chairman, University of Denver

SOUTHEASTERN: D. W. Dutton, Chairman, Georgia Institute of Technology

SOUTHWEST: H. K. Bone, Chairman, University of Oklahoma

UPPER NEW YORK-ONTARIO: B. H. Norem, Chairman, Syracuse University

COMMITTEES

ANNUAL MEETING: L. J. Lassalle, Chairman, Louisiana State University

ASSOCIATE INSTITUTIONAL MEMBERSHIP: G. D. Lobingier, Chairman, Westinghouse Electric Corp.

ATOMIC ENERGY EDUCATION: P. N. Powers, Chairman, Monsanto Chemical Co.

CONSTITUTION AND BY-LAWS: C. A. Brown, Chairman, General Motors Institute

DEGREE DESIGNATION IN COLLEGES OF ENGINEERING AND TECHNICAL INSTITUTES: J.

H. Sams, Chairman, Clemson Agricultural College

DIVISIONS AND CURRICULAR COMMITTEES: L. J. Lassalle, Chairman, Louisiana State University

ENGINEERING ECONOMY: A. E. Gruehr, Chairman, Consolidated Edison Co.

ENGINEERING SCHOOL LIBRARIES: J. H. Moriarty, Chairman, Purdue University

ETHICS: C. J. Freund, Chairman, University of Detroit

FINANCIAL POLICY: W. R. Woolrich, Chairman, University of Texas

GEORGE WESTINGHOUSE AWARD: R. S. Paffenberger, Chairman, Ohio State University

GRADUATE STUDY PROJECT (Ad Hoc): E. Weber, Chairman, Polytechnic Institute of Brooklyn

HONORARY MEMBERSHIP: M. S. Coover, Chairman, Iowa State College

HUMANISTIC-SOCIAL RESEARCH PROJECT: E. S. Burdell, Chairman, The Cooper Union

JAMES H. MCGRAW AWARD: H. R. Beatty, Chairman, Wentworth Institute

JUDGES FOR YET PAPER CONTEST: W. H. Crater, Chairman, Newark College of Engineering

LAMME AWARD: C. L. Eckel, Chairman, University of Colorado

MEMBERSHIP: J. L. Artley, Chairman, Johns Hopkins University

NOMINATING: W. R. Woolrich, Chairman, University of Texas

PUBLICATIONS: W. L. Collins, Chairman, University of Illinois

RECOGNITION AND INCENTIVES FOR GOOD TEACHING: R. W. Schmelzer, Chairman, Rensselaer Polytechnic Institute

SECTIONS AND BRANCHES: B. R. Teare, Jr., Chairman, Carnegie Institute of Technology

SOCIETY FUNCTIONS: B. R. Teare, Jr., Chairman, Carnegie Institute of Technology

TEXTILE ENGINEERING: R. Carson, Chairman, Clemson College

YOUNG ENGINEERING TEACHERS: J. L. Artley, Chairman, Johns Hopkins University

New Members

ARMANTROUT, GUY E., Teacher of Engineering-Technology, Pasadena City College, Pasadena, California. Walter L. Johnson, Robert G. Moses.

BARKO, JAMES S., Professor and Head of Graphics Department, USAF Academy, Aurora, Colorado. Archie Higdon, J. C. Hempstead.

BENSON, ROLAND A. H., Conference Leader —Distribution Training, General Motors Institute, Flint, Mich. Harold M. Dent, Earl D. Black.

BOGAN, CHARLES W., Assistant Professor of Architecture, Catholic University of America, Washington, D. C. Herbert Mannucia, Joseph C. Michalowicz.

BUCHTA, J. WILLIAM, Professor of Physics, University of Minnesota, Minneapolis, Minn. Raymond J. Seeger, G. H. Hickox.

CARTER, ARCHIE N., Manager of Highway Division, The Associated General Contractors of America, Inc., Washington, D. C. R. L. Peurifoy, Arthur J. McNair.

CASE, LLOYD N., Vice President and Dean of Men and Head of Structural Design Department, Cogswell Polytechnical College, San Francisco, California. E. W. Smith, Robert W. Dodd.

CHENG, DAVID K., Professor of Electrical Engineering, Syracuse University, Syracuse, New York. Norman Balabamion, Wilbur R. LePage.

COE, EDWARD H., Assistant Professor of Civil Engineering, University of Illinois, Navy Pier, Chicago 11, Ill. M. V. J. Dembski, Harold R. Goppert.

CRONIN, JUSTIN C., Acting Chairman of the Department of Industrial Management, Boston College, Boston, Mass. Joseph V. D'Avilla, Paul O'Donnell.

CURRAN, T. BAILEY, Head of Chemistry Department, Bridgeport Engineering Institute, Bridgeport, Conn. Arthur E. Keatz, Stanley R. O'Meara.

DREIER, THEODORE, Manager of Engineering Development, Clock and Timer Department, General Electric Company, Ashland, Mass. A. M. Anderson, M. M. Boring.

ELLER, ERNEST M., Director of Engineering, Bucknell University, Lewisburg, Pa. George A. Irland, K. L. Holderman.

FURLIN, LOUIS JR., Instructor in Technical Department, Central Technical Institute, Kansas City, Missouri. C. L. Foster, N. E. Vilander.

HALLIDAY, DAVID, Head of Department of Physics, University of Pittsburgh, Pittsburgh, Pa. R. C. Gorham, Philip E. Rush.

HARTJE, GEORGE F., Instructor in Industrial Engineering, Purdue University, Lafayette, Indiana. John M. Hayes, L. T. Wyly.

HEHNER, HARRY OMAR, Assistant Manager Technical Recruiting, Monsanto Chemical Company, St. Louis, Mo. R. M. Oliver, Gerald Nadler.

HENDERSON, PHILIP H., Placement Representative, Employee Relations, E. I. du Pont de Nemours and Company, Wilmington, Del. C. B. Hill, J. G. Buckley.

HENDRICKSON, JOE R., Professor of Applied Mechanics, Vanderbilt University, Nashville, Tenn. Fred J. Lewis, Bruce Boyer.

HERALD, CHARLES A., Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pa. J. O. Harring, V. E. Neilly.

HUGGINS, WILLIAM H., Professor of Electrical Engineering, Johns Hopkins University, Baltimore, Maryland. John L. Artley, J. T. Thompson.

HUTCHINSON, JOHN W., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. Jamison Vawter, Ellis Danner.

JONES, WINTHROP G., Instructor in Engineering, Central Technical Institute, Kansas City, Mo. C. L. Foster, N. E. Vilander.

KOENIG, J. FRANK, Assistant Professor of Electrical Engineering, Duke University, Durham, North Carolina. Edward K. Kraybill, Harry A. Owen, Jr.

KRANZBERG, MELVIN, Associate Professor of Social Studies, Case Institute of Technology, Cleveland, Ohio. F. H. Vose, Wm. W. Aubriton.

KRIEGER, HARRY, JR., Manager, Camden Engineering Personnel, Radio Corporation of

America, Camden, New Jersey. W. Leighton Collins, S. H. Pierce.

LEFLER, GLENN Q., Head and Professor of Physics, Eastern Illinois State College, Charleston, Ill. C. E. Bennett, W. Leighton Collins.

MORRIS, CHARLES, Instructor of Engineering Mechanics, New York University, New York, N. Y. F. L. Singer, Wm. G. Plumtree.

MORTON, WALTER B., Assistant Electrical Engineer, Pennsylvania Power and Light Company, Allentown, Pa. N. S. Hibshman, Allen P. Richmond, Jr.

MOYER, RICHARD L., Assistant Professor of Mechanical Engineering, University of Delaware, Newark, Del. H. L. Bueche, James I. Chower.

MCCLURE, JAMES D., in service (formerly Teaching Assistant of Department of Applied Mechanics, University of Kansas), Fort Knox, Ky. Kenneth C. Deemer, G. W. Bradshaw.

MCELRATH, GAYLE W., Associate Professor in Industrial Engineering Division, Mechanical Engineering Department, University of Minnesota, Minneapolis, Minn. A. C. Jordan, Adolph O. Lees.

MCKINNON, GORDON J., Staff Assistant, Operations Staff, Michigan Consolidated Gas Company, Detroit, Michigan.

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Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	R. M. Kerchner, Kansas State College
Michigan	Wayne University	May 6, 1956	G. H. Howell, Wayne University
Middle Atlantic	New York University	Dec. 3, 1955	C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	E. R. McKee, University of Vermont
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
*Pacific Northwest			J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
*Rocky Mountain	Denver University		W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

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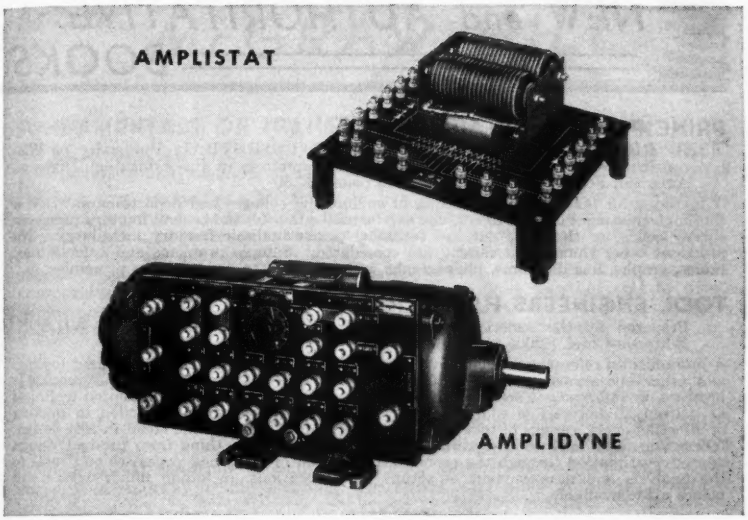

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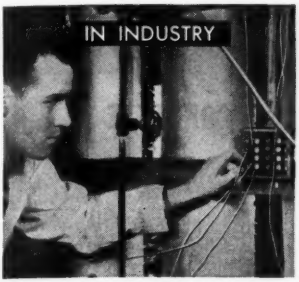

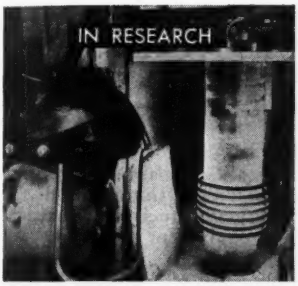

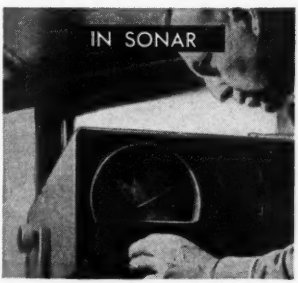

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